U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

Scientific Name:

Centrocercus urophasianus

Common Name:

Greater sage-grouse

Lead region:

Region 6 (Mountain-Prairie Region)

Information current as of:

05/15/2011

Status/Action

___ Funding provided for a proposed rule. Assessment not updated.

___ Species Assessment - determined species did not meet the definition of the endangered or threatened under the Act and, therefore, was not elevated to the Candidate status.

___ New Candidate

_X_ Continuing Candidate

___ Candidate Removal

___ Taxon is more abundant or widespread than previously believed or not subject

___ Taxon not subject to the degree of threats sufficient to warrant issuance of

___ Range is no longer a U.S. territory

___ Insufficient information exists on biological vulnerability and threats to su

___ Taxon mistakenly included in past notice of review

___ Taxon does not meet the definition of "species"

___ Taxon believed to be extinct

___ Conservation efforts have removed or reduced threats

Petition Information

___ Non-Petitioned

_X_ Petitioned - Date petition received: 01/30/2002

90-Day Positive:04/29/2008

12 Month Positive:03/23/2010

Did the Petition request a reclassification? **No**

For Petitioned Candidate species:

Is the listing warranted(if yes, see summary threats below) **Yes**

To Date, has publication of the proposal to list been precluded by other higher priority listing? **Yes**

Explanation of why precluded:

Higher priority listing actions, including court-approved settlements, court-ordered and statutory deadlines for petition findings and listing determinations, emergency listing determinations, and responses to litigation, continue to preclude the proposed and final listing rules for this species. We continue to monitor populations and will change its status or implement an emergency listing if necessary. The Progress on Revising the Lists section of the current CNOR (http://endangered.fws.gov/) provides information on listing actions taken during the last 12 months.

Historical States/Territories/Countries of Occurrence:

- **States/US Territories**: Arizona, California, Colorado, Idaho, Montana, Nebraska, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, Wyoming
- **US Counties**:County information not available
- **Countries**: Canada

Current States/Counties/Territories/Countries of Occurrence:

- **States/US Territories**: California, Colorado, Idaho, Montana, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, Wyoming
- **US Counties**: Modoc, CA, Alamosa, CO, Chaffee, CO, Costilla, CO, Lake, CO, Larimer, CO, Park, CO, Rio Grande, CO, Saguache, CO, Ada, ID, Adams, ID, Bannock, ID, Bear Lake, ID, Bingham, ID, Blaine, ID, Boise, ID, Bonneville, ID, Butte, ID, Camas, ID, Canyon, ID, Caribou, ID, Cassia, ID, Clark, ID, Custer, ID, Elmore, ID, Fremont, ID, Gem, ID, Gooding, ID, Jefferson, ID, Jerome, ID, Lemhi, ID, Lincoln, ID, Madison, ID, Minidoka, ID, Oneida, ID, Owyhee, ID, Payette, ID, Power, ID, Twin Falls, ID, Valley, ID, Washington, ID, Beaverhead, MT, Big Horn, MT, Blaine, MT, Broadwater, MT, Carbon, MT, Carter, MT, Chouteau, MT, Custer, MT, Dawson, MT, Fallon, MT, Fergus, MT, Gallatin, MT, Garfield, MT, Golden Valley, MT, Hill, MT, Liberty, MT, Madison, MT, McCone, MT, Meagher, MT, Musselshell, MT, Park, MT, Petroleum, MT, Phillips, MT, Powder River, MT, Prairie, MT, Richland, MT, Rosebud, MT, Silver Bow, MT, Stillwater, MT, Sweet Grass, MT, Treasure, MT, Valley, MT, Wheatland, MT, Wibaux, MT, Yellowstone, MT, Bowman, ND, Golden Valley, ND, Slope, ND, Baker, OR, Crook, OR, Deschutes, OR, Grant, OR, Harney, OR, Klamath, OR, Lake, OR, Malheur, OR, Union, OR, Wheeler, OR, Butte, SD, Fall River, SD, Harding, SD, Beaver, UT, Box Elder, UT, Cache, UT, Carbon, UT, Daggett, UT, Duchesne, UT, Emery, UT, Garfield, UT, Grand, UT, Iron, UT, Juab, UT, Kane, UT, Millard, UT, Morgan, UT, Piute, UT, Rich, UT, Sanpete, UT, Sevier, UT, Summit, UT, Tooele, UT, Uintah, UT, Utah, UT, Wasatch, UT, Wayne, UT, Weber, UT, Benton, WA, Douglas, WA, Grant, WA, Kittitas, WA, Okanogan, WA, Yakima, WA, Albany, WY, Big Horn, WY, Campbell, WY, Carbon, WY, Converse, WY, Crook, WY, Fremont, WY, Hot Springs,

WY, Johnson, WY, Laramie, WY, Lincoln, WY, Natrona, WY, Niobrara, WY, Park, WY, Platte, WY, Sheridan, WY, Sublette, WY, Sweetwater, WY, Teton, WY, Uinta, WY, Washakie, WY, Weston, WY

- **Countries**: Canada

Land Ownership:

The majority of Greater sage-grouse extant habitats occur on Federal surfaces. The Bureau of Land Management (BLM) manages 52 percent of sage-grouse habitats, while the U.S. Forest Service (USFS) is responsible for management of approximately 8 percent of sage-grouse habitat. The Bureau of Indian Affairs (BIA) owns approximately 3 percent of sage-grouse habitat, while other Federal agencies, including the U.S. Fish and Wildlife Service (Service), Bureau of Reclamation (BOR), National Park Service (NPS), Department of Defense (DOD), and Department of Energy (DOE) are cumulatively responsible for approximately 1 percent of sage-grouse habitats. State agencies manage approximately 5 percent of sage-grouse habitats. The remaining 31 percent of sage-grouse habitats are in private ownership (Table 1).

TABLE 1. Percent surface ownership of total sagebrush area (km2 (mi2)) within the sage-grouse management zones (from Knick 2011, p. 26). Other Federal agencies include the Service, BOR, NPS, DOD, and DOE. MZ VII includes both Gunnison and greater sage-grouse.

			Sagebrush Management and Ownership					
			BLM	Private	USFS	State	BIA	Other Federal
Sage-grouse MZ	km^2	mi^2	Percent					
I Great Plains	50,264	19,407	17	66	2	7	4	3
II Wyoming Basins	108,771	41,996	49	35	4	7	4	1
III Southern Great Basin	92,173	35,588	73	13	10	3	1	0
IV Snake River Plain	134,187	51,810	53	29	11	6	1	0
V Northern Great Basin	65,536	25,303	62	21	10	1	1	6
VI Columbia Basin	12,105	4,674	6	64	2	12	13	3
VII Colorado Plateau	17,534	6,770	42	36	6	6	9	1
TOTALS	480,570	185,549	52	31	8	5	3	1

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Biological Information

Species Description:

The greater sage grouse is the largest North American grouse species. Adult male greater sage-grouse range in length from 66 to 76 centimeters (cm) (26 to 30 inches (in.)) and weigh between 2 and 3 kilograms (kg) (4 and 7 pounds (lb)). Adult females are smaller, ranging in length from 48 to 58 cm (19 to 23 in.) and weighing between 1 and 2 kg (2 and 4 lb). Males and females have dark grayish brown body plumage with many small gray and white speckles, fleshy yellow combs over the eyes, long pointed tails, and dark green toes. Males also have blackish chin and throat feathers, conspicuous phylloplumes (specialized erectile feathers) at the back of the head and neck, and white feathers forming a ruff around the neck and upper belly. During breeding displays, males exhibit olive green apteria (fleshy bare patches of skin) on their breasts (Schroeder et al. 1999, p. 2).

Taxonomy:

Greater sage-grouse are members of the Phasianidae family. They are one of two congeneric species; the other species in the genus is the Gunnison sage-grouse (Centrocercus minimus). In 1957, the American Ornithologists' Union (AOU) (AOU 1957, p. 139) recognized two subspecies of the greater sage-grouse, the eastern (Centrocercus urophasianus urophasianus) and western (C. u. phaios) based on information from Aldrich (1946, p. 129). The original subspecies designation of the western subspecies was based solely on differences in coloration (specifically, reduced white markings and darker feathering on western birds) among 11 museum specimens collected from 8 locations in Washington, Oregon, and California. The last edition of the AOU Check-list of North American Birds to include subspecies was the 5th Edition, published in 1957. Subsequent editions of the Check-list have excluded treatment of subspecies. The AOU explained that its decision to omit subspecies, "carries with it our realization that an uncertain number of currently recognized subspecies, especially those formally named early in this century, probably cannot be validated by rigorous modern techniques." (AOU, 7th Ed., 1998, p. xii)

Since the publication of the 1957 Check-list, the validity of the subspecies designations for greater sage-grouse has been questioned, and in some cases dismissed, by several credible taxonomic authorities (Johnsgard 1983, p. 109; Drut 1994, p. 2; Schroeder et al. 1999, p. 3; International Union for Conservation of Nature (IUCN) 2000, p. 62; Banks 2000, 2002 pers. comm.; Johnsgard 2002, p. 108; Benedict et al. 2003, p. 301; Connelly et al. 2004, pp. 8-4 to 8-5). In our 2010 status review of the Greater sage-grouse (75 FR 13910), we reviewed data on the geographic separation of the putative subspecies, behavior, morphology, and genetics to assess the biological validity of the subspecies designation. Details of our analyses can be found within that status review (75 FR 13912-13915). In summary, there does not appear to be any clear and consistent geographic separation between sage-grouse historically described as "eastern" and "western." Banks (1992) and Schroeder (2008, p. 9) both found morphological variations between individuals and populations, but Banks stated that the differences would not be sufficient to recognize subspecies by current taxonomic standards, and Schroeder noted that the differences were not consistent with any of the described geographic or genetic delineations between putative subspecies. Schroeder (2008 p. 9) also noted regional behavior differences in strut rate, but stated it was not clear if this variation reflected population-level effects. Finally, the best available genetic information indicates there is no distinction between the putative western and eastern subspecies (Benedict et al. 2003, p. 309; Oyler-McCance and Quinn 2011, p. 91). Therefore, as concluded in our March 2010 status review, we do not consider the historically designated subspecies of the greater sage-grouse to be valid taxonomic entities. However, we still consider the greater sage-grouse to be a listable entity at the species level, and therefore evaluate that entity in this assessment.

Habitat/Life History:

A detailed description of seasonal habitats, sage-grouse natural history and population trend analyses can be found in our March 2010 status review (75 FR 13915-13924). The following abbreviated discussion provides the key points necessary for understanding of the recommended status for this species.

Greater sage grouse depend on a variety of shrub steppe habitats throughout their life cycle, and are considered obligate users of several species of sagebrush (e.g., Artemisia tridentata ssp. wyomingensis (Wyoming big sagebrush), A. t. ssp. vaseyana (mountain big sagebrush), and A. t. tridentata (basin big sagebrush)) (Patterson 1952, p. 48; Braun et al. 1976, p. 168; Connelly et al. 2000a, pp. 970-972; Connelly et al. 2004, p. 4-1; Miller et al. 2011, p. 147). Greater sage-grouse also use other sagebrush species such as A. arbuscula (low sagebrush), A. nova (black sagebrush), A. frigida (fringed sagebrush), and A. cana silver sagebrush (Schroeder et al. 1999, pp. 4-5; Connelly et al. 2004, p. 3-4). Thus, sage-grouse distribution is strongly correlated with the distribution of sagebrush habitats (Schroeder et al. 2004, p. 364). Sage-grouse exhibit strong site fidelity (loyalty to a particular area even when the area is no longer of value) to seasonal habitats, which include breeding, nesting, brood rearing, and wintering areas (Connelly et al. 2004, p. 3-1). Adult sage-grouse rarely switch between these habitats once they have been selected, limiting their adaptability to changes.

During the spring breeding season, male sage grouse gather together to perform courtship displays on areas called leks. Areas of bare soil, short grass steppe, windswept ridges, exposed knolls, or other relatively open sites typically serve as leks (Patterson 1952, p. 83; Connelly et al. 2004, p. 3-7 and references therein). Leks are often surrounded by denser shrub steppe cover, which is used for escape, thermal and feeding cover. The proximity, configuration, and abundance of nesting habitat are key factors influencing lek location (Connelly et al., 1981, and Connelly et al., 2000 b, cited in Connelly et al., 2011a, p. 62).). Leks can be formed opportunistically at any appropriate site within or adjacent to nesting habitat (Connelly et al. 2000a, p. 970) and, therefore, lek habitat availability is not considered to be a limiting factor for sage-grouse (Schroeder 1999, p. 4). Nest sites are selected independent of lek locations, but the reverse is not true (Bradbury et al. 1989, p. 22; Wakkinen et al. 1992, p. 382). Thus, leks are indicative of nesting habitat.

Numerous researchers have observed that a relatively small number of dominant males account for the majority of copulations on each lek (Schroeder et al. 1999, p. 8). However, Bush (2009, p. 106) found on average that 45.9 percent (range 14.3 to 54.5 percent) of genetically identified males in a population fathered offspring in a given year which indicates that males and females likely engage in off-lek copulations. However, concern does remain that effective population sizes may contribute to a reduction of genetic diversity in sage-grouse, particularly in isolated populations, or areas with extensive habitat fragmentation (Bush et al. 2011, p. 528). Males do not participate in incubation of eggs or rearing chicks.

Productive nesting areas are typically characterized by sagebrush with an understory of native grasses and forbs, with horizontal and vertical structural diversity that provides an insect prey base, herbaceous forage for pre-laying and nesting hens, and cover for the hen while she is incubating (Gregg 1991, p. 19; Schroeder et al. 1999, p. 4; Connelly et al. 2000a, p. 971; Connelly et al. 2004, pp. 4-17, 18; Connelly et al. 2011b, p. 74). Shrub canopy and grass cover provide concealment for sage grouse nests and young, and are critical for reproductive success (Barnett and Crawford 1994, p.116; Gregg et al. 1994, p. 164; DeLong et al.1995, p. 90; Connelly et al. 2004, p. 4-4). Vegetation characteristics of successful nest sites include a sagebrush canopy cover of 15-25 percent, sagebrush heights of 30 to 80 cm (11.8 to 31.5 in.), and grass/forb cover of 18 cm (7.1 in.) (Connelly et al. 2000a, p. 977). Females have been documented to travel more than 20 km (12.5 mi) to their nest site after mating (Connelly et al. 2000a, p. 970), but distances between a nest site and the lek on which breeding occurred is variable (Connelly et al. 2004, pp. 4-5). Average distance between a female's nest and the lek on which she was first observed ranged from 3.4 km (2.1 mi) to 7.8 km (4.8 mi) in five studies examining 301 nest locations (Schroeder et al. 1999 p. 12).

Adult female sage-grouse have higher nest initiation rates than yearling females (Connelly et al. 2011 a, p. 63). Nest success (one or more eggs hatching from a nest), as reported in the scientific literature, varies widely (15-86 percent Schroeder et al. 1999, p. 11). Overall, the average nest success for sage-grouse in habitats where sagebrush has not been disturbed is 51 percent and for sage-grouse in disturbed habitats is 37 percent (Connelly et al., in press a, p. 1). Re-nesting only occurs if the original nest is lost (Schroeder et al. 1999, p. 11). Sage-grouse re-nesting rates average 28.9 percent (based on 9 different studies) with a range from 5 to 41 percent (Connelly et al. 2004. p. 3-11). Other game bird species have much higher re-nesting rates, often exceeding 75 percent.

Little information is available on the level of productivity (number of chicks per hen that survive until fall) that is necessary to maintain a stable population (Connelly et al. 2000b, p. 970). However, Connelly et al. (2000b, p. 970, and references therein) suggest that 2.25 chicks per hen per year are necessary to maintain stable to increasing populations. Despite average clutch sizes of 7 eggs (Connelly et al. 2011a, p. 62) due to low chick survival and limited re-nesting, there is little evidence that populations of sage-grouse produce large annual surpluses (Connelly et al. 2011a, p. 67). Forbs and insects are essential nutritional components for chicks (Klebenow and Gray 1968, p. 81; Johnson and Boyce 1991, p. 90; Connelly et al. 2004, p. 4-9). Therefore, early brood-rearing habitat must provide adequate cover (sagebrush canopy cover of 10 to 25 percent; Connelly et al. 2000a, p. 977) adjacent to areas rich in forbs and insects to ensure chick survival during this period (Connelly et al. 2004, p. 4-9).

All sage-grouse gradually move from sagebrush uplands to more mesic areas (moist areas such as streambeds or wet meadows) during the late brood-rearing period (3 weeks post-hatch) in response to summer desiccation of herbaceous vegetation (Connelly et al. 2000a, p. 971). Summer use areas can include sagebrush habitats as well as riparian areas, wet meadows and alfalfa fields (Schroeder et al. 1999, p. 4). These areas provide an abundance of forbs and insects for both hens and chicks (Schroeder et al. 1999, p. 4; Connelly et al. 2000a, p. 971). Sage-grouse will use free water although they do not require it since they obtain their water needs from the food they eat. However, natural water bodies and reservoirs can provide mesic areas for succulent forb and insect production, thereby attracting sage-grouse hens with broods (Connelly et al. 2004, p. 4-12).

As vegetation continues to desiccate through the late summer and fall, sage-grouse shift their diet entirely to sagebrush (Schroeder et al. 1999, p. 5). Sage-grouse depend entirely on sagebrush throughout the winter for both food and cover. Sagebrush stand selection is influenced by snow depth (Patterson 1952, p. 184; Hupp and Braun 1989, p. 827), availability of sagebrush above the snow to provide cover (Connelly et al. 2004, pp. 4-13, and references therein) and, in some areas, topography (e.g., elevation, slope and aspect; Beck 1977, p. 22; Crawford et al. 2004, p. 5).

Many populations of sage-grouse migrate between seasonal ranges in response to habitat distribution (Connelly et al. 2004, p. 3-5). Migration can occur between winter and breeding and summer areas, between breeding, summer and winter areas, or not at all. Migration distances of up to 161 km (100 mi) have been recorded (Patterson 1952, p.189); however, distances vary depending on the locations of seasonal habitats (Schroeder et al. 1999, p. 3). Almost no information is available regarding the distribution and characteristics of migration corridors for sage-grouse (Connelly et al. 2004, p. 4-19). Sage-grouse dispersal (permanent moves to other areas) is poorly understood (Connelly et al. 2004, p. 3-5) and appears to be sporadic (Dunn and Braun 1986, p. 89). Estimating an “average” home range for sage-grouse is difficult due to the large variation in sage-grouse movements both within and among populations. This variation is related to the spatial availability of habitats required for seasonal use and annual recorded home ranges have varied from 4 to 615 square kilometers (km2) (1.5 to 237.5 square miles (mi2)); Connelly et al., 2011a, p. 60).

Sage grouse typically live between 3 and 6 years, but individuals up to 9 years of age have been recorded in the wild (Connelly et al. 2004, p. 3-12). Hens typically survive longer due to the disproportionate impact of predation on leks to males (Schroeder et al. 1999, p. 14). Juvenile survival (from hatch to first breeding season) is affected by food availability, habitat quality, harvest, and weather. Variation in juvenile mortality rates may be associated with gender, weather, harvest rates, age of brood female (broods with adult females have higher survival), and with habitat quality (rates of mortality increase in poor habitats) (Schroeder et al. 1999, p. 14; Connelly et al., 2011a, p.65). The average annual survival rate ranges from 38 to 60 percent for male sage grouse (all ages combined) and 55 to 75 percent for females (Schroeder et al. 1999, p. 14). Although seasonal patterns of mortality have not been thoroughly examined, over-winter mortality appears to be low (Connelly et al. 2000b, p. 229; Connelly et al. 2004, p. 9-4). While both males and females are capable of breeding the first spring after hatch, young males are rarely successful due to the dominance of older males on the lek (Schroeder et al. 1999, p. 14). Nesting rates of yearling females are 25 percent less than adult females (Schroeder et al. 1999, p. 13).

Sage-grouse are dependent on large areas of contiguous sagebrush (Patterson 1952, p. 48; Connelly et al. 2004, p. 4-1; Connelly et al. 2011a, p. 60; Wisdom et al. in press, p. 4), and large-scale characteristics (e.g. agricultural conversions within surrounding landscapes influence sage-grouse habitat selection (Knick and Hanser 2011, p. 41). Sagebrush is the most widespread vegetation in the intermountain lowlands in the western United States (West and Young 2000, p. 259) and is considered one of the most imperiled ecosystems in North America due to continued degradation and lack of protection (Knick et al. 2003, p. 612; Miller et al. 2011 p. 147, and references therein). Sagebrush species and subspecies occurrence in an area is dictated by local soil type, soil moisture, and climatic conditions (West 1983, p. 333; West and Young 2000, p. 260; Miller et al. 2011, pp. 148-151). The degree of dominance by sagebrush varies with local site conditions and disturbance history. Plant associations, typically defined by perennial grasses, further define distinctive sagebrush communities (Miller and Eddleman 2000, pp. 10-14; Connelly et al. 2004, p. 5-3), and are influenced by topography, elevation, precipitation and soil type. These ecological conditions influence the response and resiliency of sagebrush and their associated understories to natural and human-caused changes. Sagebrush that provide important annual and seasonal habitats for sage-grouse include three subspecies of big sagebrush (A. t. ssp. wyomingensis, A. t. ssp. tridentata and A. t. ssp. vaseyana), two low forms of sagebrush (A. arbuscula (little sagebrush) and A. nova) and A. cana ssp. cana) Miller et al. 2011, p. 149).

Sagebrush is long-lived, with plants of some species surviving up to 150 years (West 1983, p. 340). They produce chemicals that reduce seed germination, seedling growth and root respiration of competing plant species and inhibit the activity of soil microbes and nitrogen fixation. Sagebrush has resistance to environmental extremes, with the exception of fire and occasionally defoliating insects (e.g., webworm (Aroga spp.); West 1983, p. 341). Most species of sagebrush are killed by fire (West 1983, p. 341; Miller and Eddleman 2000, p. 17; West and Young 2000, p. 259), and historic fire-return intervals were as long as 350 years, depending on sagebrush type and environmental conditions (Baker in press, p. 16). Natural sagebrush recolonization in burned areas depends on the presence of adjacent live plants for a seed source or on the seed bank, if present (Miller and Eddleman 2000, p. 17), and requires decades for full recovery. Although seed viability and germination are high, seed dispersal is limited. Sagebrush seeds, depending on the species, remain viable for 1 to 3 years. In years of drought, sagebrush may not flower.

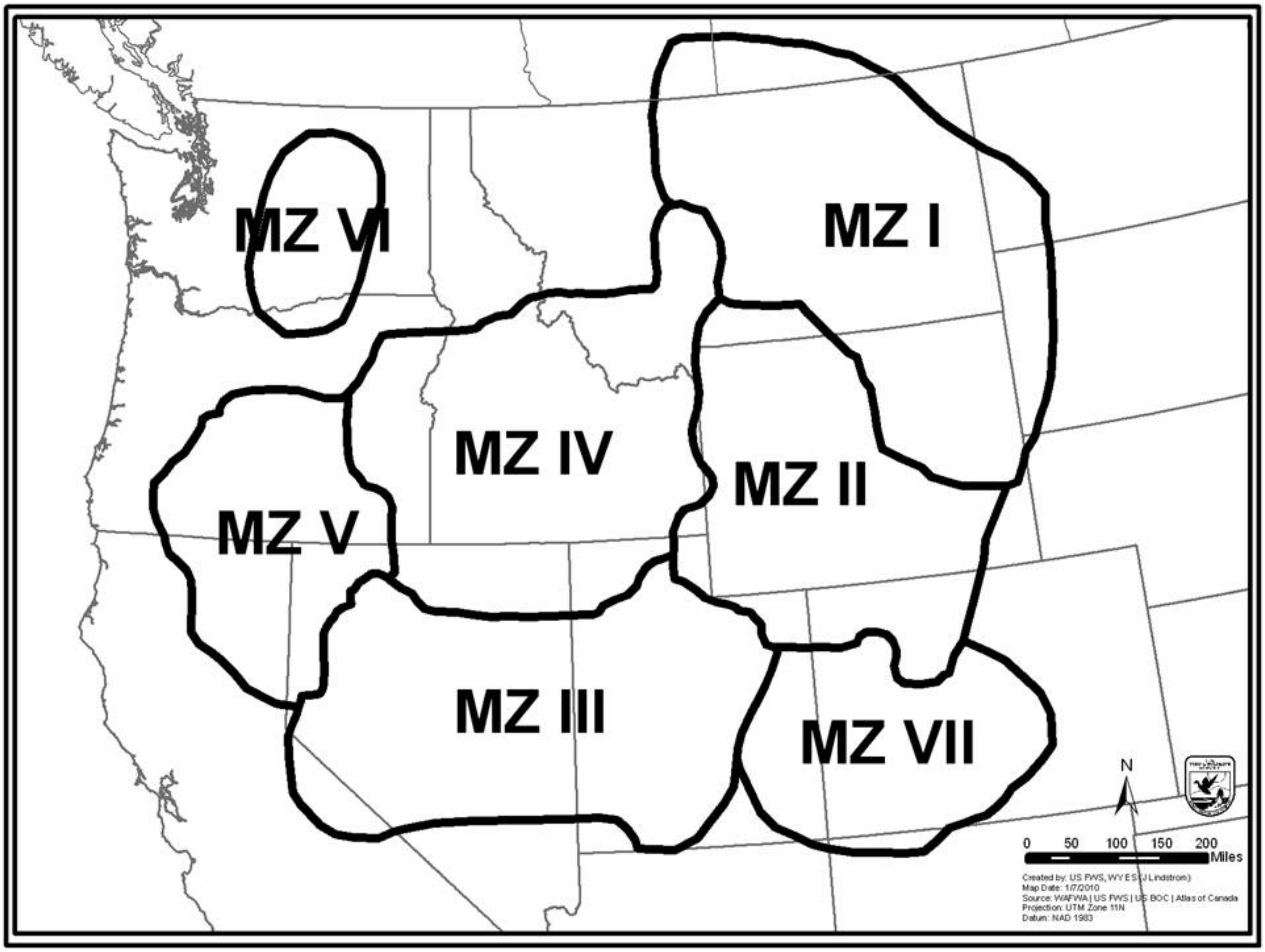
Plants associated with the sagebrush understory vary, as does their productivity. Both plant composition and productivity are influenced by moisture availability, soil characteristics, climate, and topographic position (Miller et al.,2011, pp. 149-151). Forb abundance can be highly variable from year to year and is largely affected by the amount and timing of precipitation.

Very little sagebrush within its extant range is undisturbed or unaltered from its condition prior to EuroAmerican settlement in the late 1800s (Knick et al. 2003, p. 612, and references therein). Due to the disruption of primary patterns, processes and components of sagebrush ecosystems since EuroAmerican settlement (Knick et al. 2003, p. 612; Miller et al. 2011, p. 147), the large range of abiotic variation, the minimal short-lived seed banks, and the long generation time of sagebrush, restoration of disturbed areas is very difficult. Not all areas previously dominated by sagebrush can be restored because alteration of vegetation, nutrient cycles, topsoil, and living (cryptobiotic) soil crusts has exceeded recovery thresholds (Knick et al. 2003, p. 620). Additionally, processes to restore sagebrush ecology are relatively unknown (Knick et al. 2003, p. 620). Active restoration activities are often limited by financial and logistic resources and lack of political motivation (Knick et al. 2003, p. 620; Miller et al. 2011, p. 147) and may require decades or centuries (Knick et al. 2003, p. 620, and references therein). Meaningful restoration for greater sage-grouse requires landscape, watershed, or eco-regional scale context rather than individual, unconnected efforts (Knick et al. 2003, p. 623, and references therein; Wisdom et al. 2011, p. 465). Landscape restoration efforts require a broad range of partnerships (private, State, and Federal) due to landownership patterns (Knick et al. 2003, p. 623; see discussion of landownership above).

Greater sage-grouse require large, interconnected expanses of sagebrush with healthy, native understories (Patterson 1952, p. 9; Knick et al. 2003, p. 623; Connelly et al. 2004, pp. 4-15; Connelly et al. 2011a, p. 67; Pyke 2011, p. 534; Wisdom et al. 2011, p. 45). There is little information available regarding minimum sagebrush patch sizes required to support populations of sage-grouse. This is due in part to the migratory nature of some, but not all sage-grouse populations, the lack of juxtaposition of seasonal habitats, and differences in local, regional and range-wide ecological conditions which influence the distribution of sagebrush and associated understories. Where home ranges have been reported (Connelly et al. a, p. 60 and references therein), they are extremely variable (4 to 615 km2 range (1.5 to 237.5 mi2)). Occupancy of a home range also is based on multiple variables associated with both local vegetation characteristics and landscape characteristics (Knick et al. 2003, p. 621). Pyke (2011, p. 540) estimated that greater than 4,000 ha (9,884 ac) was necessary for population sustainability. However, he did not indicate whether this value was for migratory or non-migratory populations, nor if this included juxtaposition of all seasonal habitats. Large seasonal and annual movements emphasize the large landscapes required by the greater sage-grouse (Knick et al. 2003, p. 624; Connelly et al. 2011a, p. 60).

Due to differences in the ecology of sagebrush across the range of the greater sage-grouse, the Western Association of Fish and Wildlife Agencies (WAFWA) delineated seven Management Zones (MZs I-VII) based primarily on floristic provinces (Figure 1; Stiver et al. 2006, p. 1-6). The boundaries of these MZs were delineated based on their ecological and biological attributes rather than on arbitrary political boundaries (Stiver et al. 2006, p. 1-6). Therefore, vegetation found within a MZ is similar and sage-grouse and their habitats within these areas are likely to respond similarly to environmental factors and management actions. The WAFWA conservation strategy also includes the Gunnison sage-grouse (C. minimus) and the boundary for MZ VII includes its range (Stiver et al. 2006, pp. 1-1, 1-8), which does not overlap with the the range of the greater sage-grouse.

FIGURE 1. The MZs for sage-grouse as identified by Stiver et al. (2006, p. 1-11.; The delineation is primarily based on floristic provinces and population boundaries.



The loss of sagebrush habitats from fragmentation and conversion decreases the connectivity between greater sage-grouse seasonal habitats, potentially resulting in the loss of populations (Doherty et al. 2008, p. 194; Carpenter et al. 2010, p. 1813). Loss of connectivity also can increase population isolation (Knick and Hanser 2011, p. 384, and references therein) and, therefore, the probability of loss of genetic diversity and extirpation from stochastic events (Perkins 2010, p. 86; Bush et al. 2011, p. 537)

Analyses of connectivity of greater sage-grouse across the sagebrush landscape were conducted by Knick and Hanser (2011, entire). The average movement between leks of sage-grouse rangewide was 16.6 km (10.3 mi), with a standard deviation of 7.3 km (4.5 mi) (Knick and Hanser 2011, p. 390). Genetic evidence suggests that exchange of individual birds has historically not been restricted, although there is a gradation of allelic frequencies across the species' range (Oyler-McCance and Quinn, 2011, p. 91). This result suggests that widespread movements (e.g., across several States) are not occurring.

Analyses of population linkages indicated that sage-grouse primarily occurred within MZs, and connectivity between MZs was limited, with the exception of MZs I (Great Plains) and II (Wyoming Basin). Within MZs, the Wyoming Basin (MZ II) had the highest levels of connectivity, followed by MZ IV (Snake River Plain) and MZ I (Great Plains) (Knick and Hanser 2011, pp. 390-391). The MZ VI (Columbia Basin) and VII (Colorado Plateau) had the least internal connectivity, suggesting there was limited dispersal between leks and an existing relatively high degree of isolation (Knick and Hanser 2011, p. 390). Areas along the edges of the sage-grouse range (e.g., Columbia Basin, Bi-State area) are currently isolated from other sage-grouse populations (Knick and Hanser 2011, p. 402).

Analyses showed that sagebrush distribution was the most important factor in maintaining connectivity (Knick and Hanser 2011, p. 404). This result suggests that any activities which remove or fragment sagebrush habitats will contribute to loss of connectivity and population isolation. This conclusion is consistent with research from both Aldridge et al. (2008, p. 988) and Wisdom et al. (2011, p. 461), which independently identified the proximity of sagebrush patches and area in sagebrush cover as the best predictors for sage-grouse presence. Additionally, Bush et al. (2011, p. 537) identified long-term loss of sagebrush habitats as a significant contributor to population declines and genetic differentiation in northern Montana and Alberta.

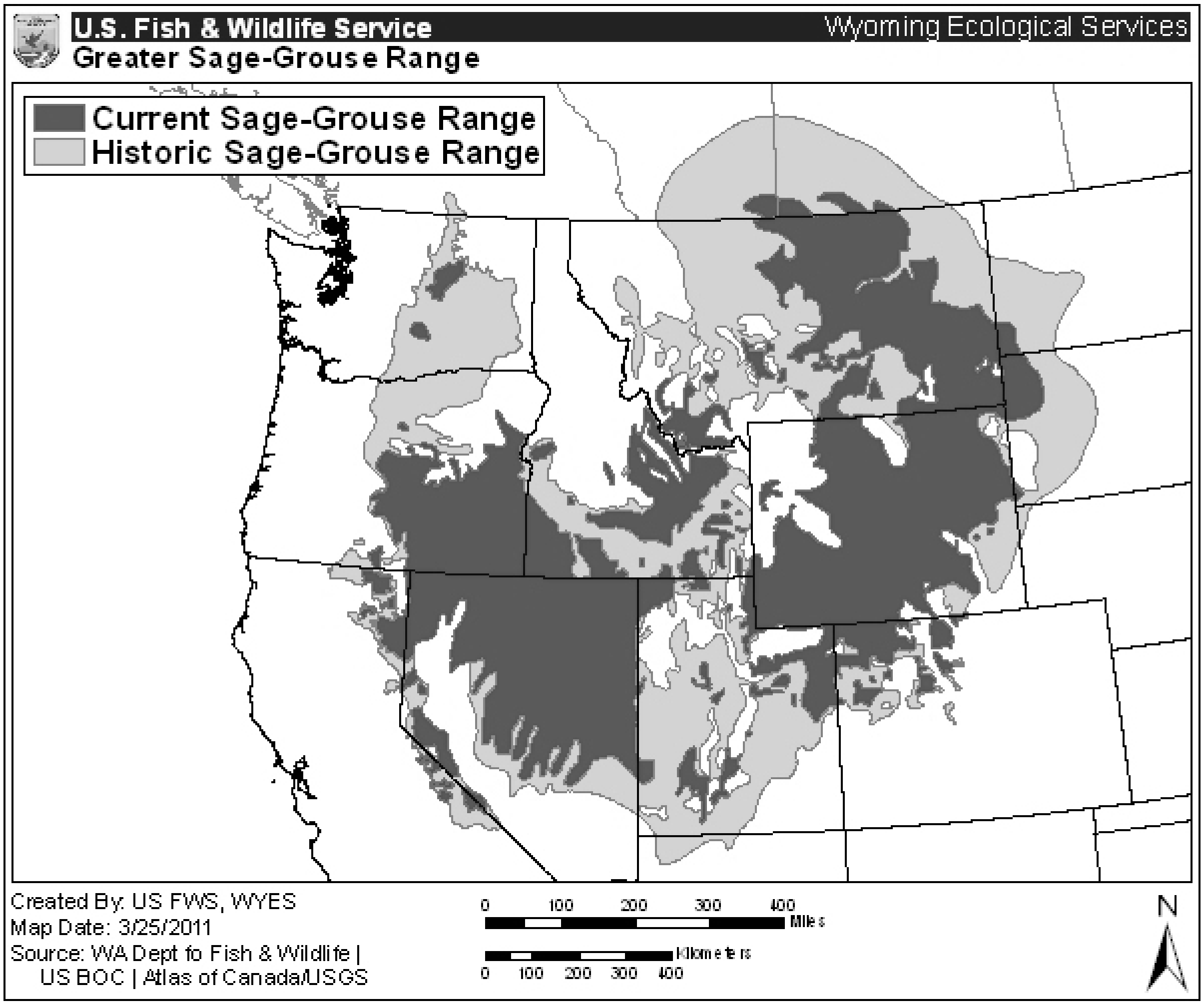
Historical Range/Distribution:

Prior to settlement of western North America by European immigrants in the 19th century, greater sage grouse occurred in 13 States and 3 Canadian provinces—Washington, Oregon, California, Nevada, Idaho, Montana, Wyoming, Colorado, Utah, South Dakota, North Dakota, Nebraska, Arizona, British Columbia, Alberta, and Saskatchewan (Schroeder et al. 1999, p. 2; Young et al. 2000, p. 445; Schroeder et al. 2004, p. 369). Sagebrush habitats that potentially supported sage-grouse occurred over approximately 1,200,483 km2 (463,509 mi2) before 1800 (Schroeder et al. 2004, p. 366).

Current Range Distribution:

Currently, greater sage grouse occur in 11 States (Washington, Oregon, California, Nevada, Idaho, Montana, Wyoming, Colorado, Utah, South Dakota, and North Dakota), and 2 Canadian provinces (Alberta and Saskatchewan), occupying approximately 56 percent of their historical range (Schroeder et al. 2004, p. 369). Approximately 2 percent of the total range of the greater sage-grouse occurs in Canada, with the remainder in the United States (Knick 2011, p. 24). Sage grouse have been extirpated from Nebraska, British Columbia, and possibly Arizona (Schroeder et al. 1999, p. 2; Young et al. 2000 p. 445; Schroeder et al. 2004, p. 369). Current distribution of the greater sage-grouse is estimated at 668,412 km2 (258,075 mi2; Connelly et al. 2004, p. 6-9; Schroeder et al. 2004, p. 369). Changes in distribution are the result of sagebrush alteration and degradation (Schroeder et al. 2004, p. 363).

Figure 2: Current and Historic (“pre-settlement”) distribution of the Greater sage-grouse.



Population Estimates/Status:

Estimates of greater sage-grouse abundance were mostly anecdotal prior to the implementation of systematic surveys in the 1950s (Braun 1998, p. 139). Early reports suggested the birds were abundant throughout their range, with estimates of historical populations ranging from 1,600,000 to 16,000,000 birds (65 FR 51580). However, concerns about extinction were raised in early literature due to market hunting and habitat alteration (Hornaday 1916, pp. 181-185). Following a review of published literature and anecdotal reports, Connelly et al. (2004, ES-1-3) concluded that the abundance of sage-grouse has declined from pre-settlement (defined as 1800) numbers. Most of the historical population changes were the result of local extirpations, which has been inferred from a 44 percent reduction in sage-grouse distribution described by Schroeder et al. 2004 (Connelly et al. 2004, p. 6-9).

Population numbers are difficult to estimate due to the large range of the species, physical difficulty in accessing some areas of habitat, the cryptic coloration and behavior of hens (Garton et al. 2011, p. 295) and survey protocols. Problems with inconsistent sampling protocols for lek surveys (e.g., number of times a lek is counted, number of leks surveyed in a year, observer bias, observer experience, time counted) were identified by Walsh et al. (2008, pp. 61-64) and Garton et al. (2011, p. 296), and many of those problems still persist (Stiver et al. 2006, p. 3-1). Additionally, estimating population sizes using lek data is difficult as the relationship of those data to actual population size (e.g., ratio of males to females, percent unseen birds) is usually unknown (WAFWA 2008, p. 3; Fedy and Aldridge 2011, p. 9). Males may also attend multiple leks in a morning, potentially inflating total population estimates (Fedy and Aldridge 2011, p. 2). However, the annual counting of males on leks remains the primary approach to monitor long-term trends of populations (WAFWA 2008, p. 3), and standardized techniques are beginning to be implemented throughout the species' range (Stiver et al. 2006, pp. 3-1 to 3-16). The use of harvest data for estimating population numbers also is of limited value since both harvest and the population size on which harvest is based are estimates. Given the limitations of these data, States usually rely on a combination of actual counts of birds on leks and harvest data to estimate population size. Estimates of populations by State, generated from a variety of data sources, are provided in Table 2.

TABLE 2. Sage-grouse Population Estimates Based on Data From State Wildlife Agencies.

Location	Data Year	Source	Estimated Population

Location	Data Year	Source	Estimated Population
CA/NV	2004	California/Nevada Sage-grouse Conservation Team (2004, p. 26)	88,000
CO	2008	2007 CO Conservation plan, based on adjusted male lek counts (count + 1.6 multiplier, sex ratio females:males) (Colorado Greater Sage-grouse Steering Committee 2008, p. 56)	22,646
ID	2007	Calculated based on assumption of 5% of population is harvested (Service, unpublished data)	98,700
MT	2007	Calculated based on assumption of 5% of population is harvested (Service, unpublished data)	62,320
ND	2007	2008 lek counts adjusted (assumes 75% of males counted at lek, & sex ratio of 2:1) (A. Robinson, NDGFD, pers. comm., 2008)	308
OR	2003	2003 Oregon Conservation Plan Estimate (Hagen 2005, p. 27)	40,000
SD	2007	South Dakota Game and Fish web page (last updated in 2007)	1,500
UT	2002	Utah Division of Wildlife Resources (2002, p. 13)	12,999
WA	2003	Washington Division of Fish and Wildlife (Stinson *et al.* 2004, p. 21)	1,059
WY	2007	Calculated based on assumption of 5% of population is harvested (Service, unpublished data)	207,560
Canada	2006	Government of Canada 2010	450

The minimum 1998 rangewide spring population numbered about 157,000 sage grouse, derived from numbers of males counted on leks (Braun 1998, p. 141). The same year, State wildlife agencies estimated the population was at least 515,000 based on lek counts and harvest data (Warren 2008, pers. comm.). In 2000, we estimated the rangewide abundance of sage grouse was between a minimum of 100,000 (taken from Braun 1998, p. 141) up to 500,000 birds (based on harvest data from Idaho, Montana, Oregon, and Wyoming, with the assumption that 10 percent of the population is typically harvested) (65 FR 51578). In 2003, based on increased lek survey efforts, Connelly et al. (2004, p. 13-5) concluded that rangewide population numbers were likely much greater than the 157,000 estimated by Braun (1998, p. 141), but they were unable to generate a rangewide population estimate. Garton et al., (2011, p. 293) estimated a rangewide minimum of 88,816 males counted on leks in 2007.

Population Trends

Although population numbers are difficult to estimate, the long-term data collected from counting males on leks provides insight to population trends. Periods of historical decline in sage grouse abundance occurred from the late 1800s to the early-1900s (Hornaday 1916, pp. 179-221; Crawford 1982, pp. 3-6; Drut 1994, pp. 2-5; Washington Department of Fish and Wildlife (WDFW) 1995; Braun 1998, p. 140; Schroeder et al. 1999, p. 1). Other noticeable declines in sage grouse populations occurred in the 1920s and 1930s, and then again in the 1960s and 1970s (Connelly and Braun 1997, pp. 3-4; Braun 1998, p. 141). Declines in the 1920s and 1930s were attributed to hunting, and declines in the 1960s and 1970s were primarily a result of loss of habitat quality and quantity (Connelly and Braun 1997, p. 2).

Using lek counts as an index for abundance, Connelly et al. (2004, p. 6-71) reported rangewide declines from 1965 through 2003. Declines averaged 2 percent per year from 1965 to 2003. The decline was more dramatic from 1965 through 1985, with an average annual change of 3.5 percent. The rate of decline rangewide slowed to 0.37 percent annually during 1986 to 2003, and some populations increased (Connelly et al. 2004, p. 6-71). Based on these analyses, Connelly et al. 2004 (p. 6-71) estimated that sage-grouse population numbers in the late 1960s and early 1970s were likely two to three times greater than current numbers (Connelly et al. 2004, p. 6-71). Using a statistical population reconstruction approach, Garton et al. (2011, p. 369) also demonstrated a pattern of higher numbers of sage-grouse in the late 1960s and early 1970s, which was supported by data from several other sources (Garton et al. 2011, p. 369).

In 2008, WAFWA conducted new population trend analyses that incorporated an additional 4 years of data beyond the Connelly et al. 2004 analysis (WAFWA 2008, entire). Although the WAFWA analyses used different statistical techniques, lek counts also were used. WAFWA results were similar to Connelly et al. (2004) in that a long-term population decline was detected during 1965 to 2007 (average 3.1 percent annually; WAFWA 2008, p. 12). WAFWA attributed the decline to the reduction in number of active leks (WAFWA 2008, p. 51). Similar to Connelly et al. (2004), the WAFWA analyses determined that the rate of decline lessened during 1985 to 2007 (average annual change of 1.4 percent annually) (WAFWA 2008, p. 58). Garton et al. (2011, pp. 369-370) also had similar results. While the average annual rate of decline has lessened since 1985 (3.1 to 1.4 percent), population declines continue and populations are now at much lower levels than in the early 1980’s. Therefore, these continuing negative trends at such low relative numbers are a concern with regard to long-term population persistence. Similarly, short-term increases or stable trends, which may seem encouraging on the surface, do not indicate that populations are recovering, but may instead be a function of losing leks and not increases in numbers (WAFWA 2008, p.51). Population stability may also be compromised if cycles in sage-grouse populations (Schroeder et al. 1999, p. 15; Connelly et al. 2004, p.6-71; Fedy and Doherty 2011, p. 916; Fedy and Aldridge in press, p. 14) are lost, which current analyses suggest has occurred, minimizing the opportunities for population recovery if habitat were available (Garton 2009, pers. comm.).

In summary, since neither pre-settlement nor current numbers of sage-grouse are accurately known, the actual rate and magnitude of decline since pre-settlement times is uncertain. However, three groups of researchers using different statistical methods (but the same lek count data) concluded that rangewide greater sage-grouse have experienced long-term population declines in the past 43 years, with that decline lessening in the past 22 years. Many of these declines are the result of loss of leks (WAFWA 2008, p. 51), indicating either a direct loss of habitat or habitat function (Connelly and Braun 1997, p. 2). A recent increase in the annual rate of change for MZ VII may simply be an anomaly of small population numbers, as other indicators suggest this area is suffering habitat losses. A delayed response of sage-grouse to changes in carrying capacity of habitat was identified by Garton et al. (2011, p.370).

In response to a data request by the Service, States within the range of the greater sage-grouse submitted updated population trend information for 2010 (California Department of Fish and Game 2011, in litt.; Colorado Division of Wildlife 2011, in litt.; Idaho Department of Fish and Game 2011, in litt.; Montana Fish, Wildlife and Parks 2011 in litt.; Nevada Division of Wildlife 2011, in litt.; North Dakota Game and Fish 2011, in litt.; Oregon Department of Fish and Wildlife 2011, in litt.; South Dakota Department of Game, Fish and Parks 2011, in litt.; Utah Division of Wildlife Resources 2011, in litt.; Wyoming Game and Fish Department 2011, in litt.). While population trends varied across the range, all States, with the exception of North and South Dakota, indicated that the observed population fluctuations were consistent with either local population cycling or local weather conditions. We did not receive any new information concerning population trends for 2009 and 2010 in Canada from the Canadian provinces.

Both North and South Dakota experienced declining populations. North Dakota reported that sage-grouse have been declining in that state for the past 30 years, and expressed concern that continued population declines may compromise the ability to recover the genetic diversity of the species in that state (North Dakota Game and Fish 2011, in litt). South Dakota reported a 33 percent reduction in male lek counts from 2009 to 2010. Two potential causes of the decline include residual impacts on population recruitment resulting from a West Nile virus (WNv) outbreak in 2006 and 2007, or loss of nesting cover as a result of overgrazing (South Dakota Department of Game, Fish and Parks 2011, in litt.). Connelly et al. 2011c (p. 560) cautioned that aggressive habitat protection and restoration programs may be necessary to maintain the biological integrity of populations in both states, considered as fringe populations due to their location on the far eastern edge of current and historic (Schroeder et al. 2004, p. 367) sage-grouse and sagebrush distribution. This is consistent with results presented by Aldridge et al. 2008 (p. 991) who concluded that peripheral sage-grouse populations experienced greater rates of extirpation than core populations (see also Bush et al. 2011, entire).

Data from the states were not presented in a manner that allowed examination of trends by MZ. However, a rough analysis indicated that trends in 2010 varied from long-term data only in MZs IV and V, where populations generally increased or remained stable. However, extreme caution must be used in comparing one year of data with long-term trends as lek attendance data can only be reliably used for long-term data analyses (Connelly et al. 2004, p. 6-16). This is due to problems resulting from measurement error (including variation in detectability, observer acuity, and number of counts conducted for a given lek in a year (WAFWA 2008, p. 7) and temporal variation in lek attendance across a season (Garton et al. 2011, p. 296). Therefore, conclusions drawn on one year of data are not reliable.

None of the information received since our March 2010 status review indicates that population trends for the greater sage-grouse are abnormal or unexpected given local trends, events, and weather conditions. However, the continued declines in ND and SD do present concern for their long-term persistence.

Distinct Population Segment(DPS):

In our March 2010 status review for the Greater sage-grouse (75 FR 13910) we discussed the status of the previously designated Columbia Basin DPS, which is restricted to central Washington, and identified the Bi-State area populations of Nevada and California as a new DPS of the Greater sage-grouse.

On May 7, 2001, we published a 12-month finding (66 FR 22984) concluding that the Columbia Basin population of the western sage-grouse met the requirements of our DPS policy (61 FR 4722) and that listing the DPS was warranted but precluded by other higher priority listing actions. We have subsequently made resubmitted petition findings, announced in conjunction with our Candidate Notices of Review (CNOR), in which we continued to find that listing the Columbia Basin DPS of the western subspecies was warranted but precluded by other higher priority listing actions (66 FR 54811, 67 FR 40663, 69 FR 24887, 70 FR 24893, 74 FR 57803). However, as concluded in our March 2010 status review, and described above, we do not consider the historically designated western subspecies of the greater sage-grouse to be a valid taxonomic entity (75 FR 13988). As the Columbia Basin populations were determined to be DPS of the western subspecies, we agreed to re-evaluate the status of this population in the 2011 CNOR to determine if it still meets the criteria of a DPS of Greater sage-grouse based on the criteria of our DPS policy. That evaluation is being conducted independently as time and funding allows,

Based on the best scientific and commercial data available, we determined that under our DPS Policy, the Bi-State greater sage-grouse population is discreet and significant to the overall species (75 FR 13990). The Bi-State greater sage-grouse DPS historically occurred throughout most of Mono, eastern Alpine, and northern Inyo Counties, California (Hall et al. 2008, p. 97), and portions of Carson City, Douglas, Esmeralda, Lyon, and Mineral Counties, Nevada (Gullion and Christensen 1957, pp. 131–132; Espinosa 2008a, pers. comm.). The current range of the Bi-State greater sage-grouse DPS is roughly 3 percent of the area occupied by the entire Greater sage-grouse species (including the Columbia Basin). The Bi-State DPS received a listing priority number of 3, and as it has been determined to be an independent listable entity, it is being evaluated in a separate assessment. Therefore, no analysis of the Bi-State DPS has been included in this discussion of the Greater sage-grouse.

Threats

A. The present or threatened destruction, modification, or curtailment of its habitat or range:

Several recent studies have demonstrated that sagebrush area is one of the best landscape predictors of greater sage-grouse persistence (Aldridge et al. 2008, p. 987; Doherty et al. 2008, p. 191; Wisdom et al., 2011, p. 461). Sagebrush habitats are becoming increasingly degraded and fragmented due to the impacts of multiple threats, including direct conversion, urbanization, infrastructure such as roads and powerlines built in support of several activities, wildfire and the change in wildfire frequency, incursion of invasive plants, grazing, and non-renewable and renewable energy development. Many of these threat factors may be exacerbated by the effects of climate change, which may influence long-term habitat trends.

Habitat Conversion for Agriculture
An estimated 10 percent of sagebrush steppe that existed prior to EuroAmerican settlement has been converted to agriculture (Knick et al. 2011, p. 208). Habitat conversion for agricultural purposes results in loss of habitat available for sage-grouse use. The actual effect of this loss depends on the amount of sagebrush lost, the type of seasonal habitat affected, and the arrangement of habitat lost (large blocks or small patches) (Knick et al. 2011, p. 208-209). Direct impacts to sage-grouse depend on the timing of conversion (e.g., loss of nests, eggs). Indirect effects of agricultural activities adjoining sagebrush habitats include increased predation with a resulting reduction in sage-grouse nest success (Connelly et al. 2004, p. 7-23), increased human presence, and habitat fragmentation. Given the distribution of agricultural activities across the sagebrush range, nearly three quarters of all sagebrush within range of sage-grouse has been influenced by agricultural activities (Knick et al. 2011, p. 208).
A review of historic conversions of sagebrush to agricultural lands can be found in our March, 2010 status review (75 FR 13924-13925). These extensive conversions of sagebrush to agriculture has decreased abundance of sage-grouse in many portions of their range (Bush et al. 2011, p. 537; Knick and Hanser 2011, p. 401, and references therein), and agricultural tillage has been identified as a rangewide stressor to sage-grouse (Tack 2010, p. 18 and references therein). Large losses of sagebrush shrub-steppe habitats due to

agricultural conversion have occurred in in the Columbia Basin of the Northwest (MZ VI), the Snake River Plain of Idaho (MZ IV) (Schroeder et al. 2004, p. 370), and the Great Plains (MZ I) (Knick et al. 2011, p. 208). Hironaka et al. (1983, p. 27) estimated that 99 percent of basin big sagebrush habitat in the Snake River Plain has been converted to cropland. Between 1975 and 1992 alone, 29,762 ha (73,543 ac) of sagebrush habitat were converted to cropland on the Upper Snake River Plain, a 74-percent increase in cropland (Leonard et al. 2000, p. 268). The loss of this primarily winter sage-grouse habitat is significantly related to subsequent sage-grouse declines (Leonard et al. 2000, p. 268).

Agriculture is the dominant land cover within sagebrush areas of Washington (42 percent) and Idaho (19 percent) (Miller et al., 2011, p. 156). In north central Oregon (MZ V), approximately 2.6 million ha (6.4 million ac) of habitat were converted for agricultural purposes, essentially eliminating sage-grouse from this area (Willis et al. 1993, p. 35). More broadly, across the interior Columbia Basin of southern Idaho, northern Utah, northern Nevada, eastern Oregon (MZ IV) and Washington, approximately 6 million ha (14.8 million ac) of shrub-steppe habitat has been converted to agricultural crops (Altman and Holmes 2000, p. 10). Five percent of the areas occupied by Great Basin sagebrush have been converted to agriculture, urban or industrial areas (MZs III and IV) (Miller et al. 2011, p. 156). Five percent has also been converted in the wheatgrass-needlegrass-shrubsteppe (MZ II, primarily in north-central Wyoming) (Miller et al., 2011, p. 156). In sagebrush-steppe habitats, 14 percent of sagebrush habitats has been converted to agriculture, urban or industrial activities (MZs II, IV, V, and VI) (Miller et al., 2011, p. 157). Nineteen percent of the Great Plains area (MZ I) has been converted to agriculture (Knick et al. 2011, p. 208). Conversions for sagebrush habitat types by State are detailed in Table 3.

TABLE 3. Current Sagebrush-steppe Habitat and Agricultural Lands Within Great Basin Sagebrush (as derived from LANDFIRE 2006 vegetation coverage) (from Miller et al. 2011, p. 157).

STATE	PERCENT SAGEBRUSH	PERCENT AGRICULTURE
Washington	23.7	42.4
Montana	56.2*	7.5*
Wyoming	66.0*	3.4*
Idaho	55.0	18.6
Oregon	64.5	8.6
Nevada	58.7	1.3
Utah	37.6	9.7
California	49.8	8.0
Colorado	40.6*	11.8*
TOTAL	55.4	10.0

*Analyses did not include sagebrush lands in the eastern portions of Colorado, Montana and Wyoming.
Aldridge et al. (2008, pp. 990-991) reported that sage-grouse extirpations were more likely to occur in areas where cultivated crops exceeded 25 percent. Their results supported the conclusions of others (e.g., Schroeder 1997, p. 934; Braun 1998, p. 142; Aldridge and Brigham 2003, p. 30) that extensive cultivation and fragmentation of native habitats have been associated with sage-grouse population declines. Wisdom et al. (2011, p. 453) identified environmental factors associated with the regional extirpation of sage-grouse. Areas still occupied by sage-grouse have three times less area in agriculture and a mean human density 26 times lower than extirpated areas (Wisdom et al., 2011, p. 462). Agricultural conversion along the Milk River in northern Montana over the past 30 to 100 years was identified as a significant contributor to sage-grouse population decline in that area (Bush et al. 2011, pp. 536-537). While sage-grouse may forage on agricultural crops (see discussion below), they avoid landscapes dominated by agriculture (Aldridge et al. 2008, p. 991). Conversions to croplands in southern Idaho have resulted in isolation of sagebrush-dominated landscapes into less productive regions north and south of the Snake River Plain (Knick et al. 2003, p. 618). Therefore, formerly continuous populations in this area are now disconnected (Knick and Hanser 2011, p. 396). The occurrence of large leks (based on number of males attending) declined at a greater rate than the occurrence of small leks adjacent to agricultural lands in northeastern Montana (Tack 2010, p. 19). This suggests that larger populations respond rapidly to the impacts of agricultural conversion, even if leks persist. The resulting smaller populations are then more vulnerable to stochastic events (Tack 2010, p. 3).
Sagebrush habitat continues to be converted for both dryland and irrigated crop production (Montana Farm Services Agency (FSA) in litt, 2009; Braun 1998, p. 142; 65 FR 51578). The increasing value of wheat and corn crops has driven new conversions in recent years as production of these crops becomes more profitable than ranching (Tack 2010, p. 19 and references therein). For example, the area of sagebrush converted to tilled agriculture in Montana increased annually from 2005 to 2009, with approximately 10, 259 ha (25,351 ac) converted, primarily in the eastern two thirds of the State (MZ I) (Montana FSA in litt, 2009). In addition,

in 2008, a single conversion in central Montana totaled between 3,345 and 10,000 ha (10,000 and 30,000 ac) (MZ I) (Hanebury 2008a, pers. comm.). Other large conversions occurred in the same part of Montana in 2008, although these were unquantified (Hanebury 2008b, pers. comm.). In 2010 over 647.5 ha (1,600 ac) within sage-grouse range were converted for agricultural purposes in Montana under the sod busting provision of the Farm Bill (Dickerson 2010, pers. comm.). Additionally, 202.3 ha (500 ac) of sagebrush was converted for agricultural purposes in southeastern Idaho in 2010 (Idaho Fish and Game (IDFG) in litt. 2011). There are no systematic efforts to collect State or local data on conversion rates in the majority of the greater sage-grouse range (GAO 2007, p. 16). Therefore, we were unable to identify any other conversions of sage-grouse habitats in 2010.

In addition to crop conversion for traditional crops, recent interest in the development of crops for use as biofuels could potentially impact sage-grouse. For example, the 2008 Farm Bill authorized the Biomass Crop Assistance Program (BCAP), which provides financial incentives to agricultural producers that establish and produce eligible crops for conversion to bioenergy products (U.S. Department of Agriculture (USDA) 2009, p. 1). Further loss of sagebrush habitats due to BCAP will negatively impact sage-grouse populations. However, currently we have no way of predicting the magnitude of BCAP impacts to sage-grouse, nor did we receive any information specific to BCAP in our data call for this review.

Although conversion of shrub-steppe habitat to agricultural crops impacts sage-grouse through the loss of sagebrush on a broad scale, some studies report the use of agricultural crops (e.g., alfalfa) by sage-grouse. When alfalfa fields and other croplands are adjacent to extant sagebrush habitat, sage-grouse have been observed feeding in these fields, especially during brood-rearing (Patterson 1952, p. 203; Rogers 1964, p. 53; Wallestad 1971, p. 134; Connelly et al. 1988, p.120; Fischer et al. 1997, p. 89). Connelly et al. (1988, p. 120) reported seasonal movements of sage-grouse to agricultural crops as sagebrush habitats desiccated during the summer. However, use of irrigated crops may not be beneficial to greater sage-grouse if it increases exposure to pesticides (Knick et al. 2011, p. 211) and WNv (Walker et al. 2004, p. 4).

Some conversion of cropland to sagebrush has occurred in former sage-grouse habitats through the USDA's voluntary Conservation Reserve Program (CRP) which pays landowners a rental fee to plant permanent vegetation on portions of their lands, taking them out of agricultural production. Although estimates of the numbers of acres enrolled rangewide in CRP (and the number of acres soon to expire from CRP) are available, the extent of cropland conversion to habitats beneficial to sage-grouse (i.e., CRP lands planted with native grasses, forbs, and shrubs) is not known for any portion of the greater sage-grouse range, barring the Columbia Basin populations (which are discussed under the review for this DPS and therefore not included here). Thus, outside of the Columbia Basin, we cannot judge the overall impact of CRP land to sage-grouse persistence.

Urbanization

Low densities of indigenous peoples have been present for more than 12,000 years in the historical range of sage-grouse. By 1900, less than 1 person per km2 (1person per 0.4 mi2) resided in 51 percent of the 325 counties within a sage-grouse assessment area, and densities greater than 10 persons per km2 (10 persons per 0.4 mi2) occurred in 4 percent of the counties (Connelly et al. 2004, p. 7-24). By 2000, counties with less than 1 person per km2 (1 person per 0.4 mi2) occurred in 31 percent of the 325 counties and densities greater than 10 persons per km2 (10 persons per 0.4 mi2) occurred in 22 percent of the counties (Connelly et al. 2004, p. 7-25). Today, the Columbia Basin (MZ VI) has the highest density of humans within the sage-grouse rangewhile the Great Plains (MZ I) and Wyoming Basin (MZ II) have the lowest (Knick et al. 2011, p. 212). Growth in the Great Plains (MZ I) continues to be slower than other areas. For example, population densities have increased since 1990 by 7 percent in the Great Plains (MZ I), by 19 percent in the Wyoming Basin (MZ II), and by 31 percent in the Colorado Plateau (MZ VII) (Knick et al. 2011, p. 212). The dominant urban areas in the sage-grouse range are located in the Bear River Valley of Utah, the portion of Bonneville Basin southeast of the Great Salt Lake, the Snake River Valley of southern Idaho, and the Columbia River Valley of Washington (Rand McNally Road Atlas 2003; Connelly et al. 2004, p. 7-25). Overall, approximately 1 percent of the amount of potential sagebrush (estimated historic range) is now covered by lands classified as urban (Miller et al., 2011, p. 156).

Since 1950, the western U.S. population growth rate has exceeded the national average (Leu and

Hanser 2011, p. 255. This growth has led to increases in urban, suburban, and rural development. Rural development has increased especially rapidly in recent decades. For example, the amount of uninhabited area in the Great Basin ecoregion has decreased from 90,000 km2 (34,749 mi2) in 1990 to less than 12,000 km2 (4,633 mi2) in 2004 (Knick et al. 2011, p. 212). Urbanization has directly eliminated some sage-grouse habitat (Braun 1998, p. 145). Interrelated effects from urbanization include construction of associated infrastructure (e.g., roads, powerlines, and pipelines) and predation threats from the introduction of domestic pets and increases in predators subsidized by human activities. In particular, municipal solid waste landfills (landfills) and roads have been shown to contribute to increases in common raven (Corvus corax) populations (Knight et al. 1993 p. 470; Restani et al. 2001, p. 403; Webb et al. 2004, p. 523). Ravens are known to be an important predator on sage-grouse nests and have been considered a restraint on sage-grouse population growth in some locations (see Factor C, Predation) (Batterson and Morse 1948, p. 14; Autenrieth 1981, p. 45; Coates 2007, p. 26). Landfills (and roads) are found in every State within the greater sage-grouse range and a number of these are located within or adjacent to sage-grouse habitat.

Recent changes in demographic and economic trends have resulted in greater than 60 percent of the Rocky Mountain West's counties experiencing rural sprawl where rural areas are outpacing urban areas in growth (Theobald 2003, p. 3). In some Colorado counties, up to 50 percent of sage-grouse habitat is under rural subdivision development, and an estimated 3 to 5 percent of all sage-grouse historical habitat in Colorado has already been converted into urban areas (Braun 1998, p. 145). We are unaware of similar estimates for other States within the range of the greater sage-grouse and, therefore, cannot determine the effects of this factor on a rangewide basis. Rural development has increasingly taken the form of low-density (approximately 6 to 25 homes per km2 (6 to 25 homes per 0.4 mi2)) home development or exurban growth (Hansen et al. 2005, p. 1894). Between 1990 and 2000, 120,000 km2 (46,332 mi2) of land were developed at exurban densities nationally (Theobald 2001, p. 553). However, this value includes development nationwide, and we are unable to report values specifically for sagebrush habitats. However, within the Great Basin (including California, Idaho, Nevada, and Utah), human populations have increased 69 percent and un-inhabited areas declined by 86 percent between 1990 and 2004 (Leu and Hanser 2011, p. 267). Similar to higher density urbanization, exurban development has the potential to negatively affect sage-grouse populations through fragmentation or other indirect habitat loss, increased infrastructure, and increased predation. In an effort to protect sage-grouse habitat from urbanization, the Colorado Division of Wildlife (CDOW) has initiated several conservation easements and fee title acquisitions, totaling approximately 14,083 ha (34,800 ac; CDOW in litt. 2011).

In modeling sage-grouse persistence, Aldridge et al. (2008, pp. 991-992) found that the density of humans in 1950 was the best predictor of sage-grouse extirpation among the human population metrics considered (including increasing human population growth). Sage-grouse extirpation was more likely in areas having a moderate human population density of at least 4 people per km2 (4 people per 0.4 mi2) in 1950. Increasing human populations were not a good predictor of sage-grouse persistence, most likely because much of the growth occurred in areas that are already no longer suitable for sage-grouse. Aldridge et al. (2008, p. 990) also reported that, based on their models, sage-grouse require a minimum of 25 percent sagebrush for persistence in an area. A high probability of persistence required 65 percent sagebrush or more. This result is similar to the results by Wisdom et al. (2011, p. 467) who reported that human density was 26 times greater in extirpated sage-grouse areas than in currently occupied range. Therefore, human population growth that results in exurban development in sagebrush habitats will reduce the likelihood of sage-grouse persistence in the area. Given the current demographic and economic trends in the Rocky Mountain West, we believe that rates of urbanization will continue increasing, resulting in further habitat fragmentation and degradation and decreasing the probability of long-term sage-grouse persistence .

In an effort to address habitat loss due to urbanization, and other sources of development, the NRCS has engaged several private landowners in conservation easements via the Farm and Ranch Protection Program (FRPP) (NRCS 2011, in litt.). Southwestern Wyoming and northern Montana are currently the primary focus of this program Properties identified in Montana are associated with the seasonal habitats used by sage-grouse migrating out of Canada (NRCS 2011, in litt.). Loss of the wintering habitats in Montana compromises the persistence of this population, so minimizing fragmentation through conservation easements will like contribute to its long-term conservation.

Infrastructure as a Source of Fragmentation of Sagebrush Habitats

Fragmentation of sagebrush habitats has been cited as a primary cause of the decline of sage-grouse populations because the species requires large expanses of contiguous sagebrush (Patterson 1952, pp. 192-193; Connelly and Braun 1997, p. 4; Braun 1998, p. 140; Johnson and Braun 1999, p. 78; Connelly et al. 2000a, p. 975; Miller and Eddleman 2000, p. 1; Schroeder and Baydack 2001, p. 29; Johnsgard 2002, p. 108; Aldridge and Brigham 2003, p. 25; Beck et al. 2003, p. 203; Pedersen et al. 2003, pp. 23-24; Connelly et al. 2004, p. 4-15; Schroeder et al. 2004, p. 368; Leu and Hanser 2011, p. 271). Prior to 2005, detailed data to assess how fragmentation influences specific greater sage-grouse life history parameters such as productivity, density, and home range were not available. More recently, several studies have documented negative effects of fragmentation as a result of oil and gas development and its associated infrastructure (see discussion of Energy Development below) on lek persistence, lek attendance, winter habitat use, recruitment, yearling annual survival rate, and female nest site choice (Holloran 2005, p. 49; Aldridge and Boyce 2007, pp. 517-523; Walker et al. 2007a, pp. 2651-2652; Doherty et al. 2008, p. 194). Wisdom et al. (2011, p. 462) reported that a variety of human developments, including roads, energy development, and other factors that contribute to habitat fragmentation have contributed to or been associated with sage-grouse extirpation. Estimating the impact of habitat fragmentation on sage-grouse is complicated by time lags in response to habitat changes (Garton et al., 2011, p. 370), particularly since these long-lived birds will continue to return to altered breeding areas (leks, nesting areas, and early brood-rearing areas) due to strong site fidelity despite nesting or productivity failures (Wiens and Rotenberry 1985, p. 666).

Powerlines

Powerlines can directly affect greater sage-grouse by posing a collision (Borell 1939, p. 85; Braun 1998, pp. 145-146; Connelly et al. 2000a, p. 974) and electrocution (Gardner 2009, pers. comm.) hazard, and can have indirect effects by decreasing lek recruitment (Braun et al. 2002, p. 10), increasing predation (Connelly et al. 2004, p. 13-12), fragmenting habitat (Braun 1998, p. 146), and facilitating the invasion of exotic annual plants (Knick et al. 2003, p. 612; Connelly et al. 2004, p. 7-25). In 2002, there were more than 804,500 km (500,000 mi) of transmission lines (lines carrying greater than 115,000 volts (115 kilovolts (kV)) within the United States (Manville 2002, p. 4). A similar estimate is not available for distribution lines (lines carrying less than 69,000volts (69kV)), and we are not aware of data for Canada. Within sagebrush habitats Knick et al. (2011, p. 213) showed that powerlines cover a minimum of 1,089km2 (420.5 mi). Due to the potential spread of invasive species and predators as a result of powerline construction, the impact from powerlines is greater than the actual footprint. Knick et al. (2011, p. 213) estimated these impacts may influence up to 39 percent of all sagebrush. There are no published experimental studies that provide a clear analysis of the impacts of tall structures, including power poles, on sage-grouse (Utah Wildlife In Need (UWIN) 2010, p. 12). However, the following summary identifies the potential impacts of powerlines on sage-grouse and their habitats.

In areas where the vegetation is low and the terrain relatively flat, power poles provide an attractive hunting and roosting perch, as well as nesting stratum for many species of raptors and corvids (Steenhof et al. 1993, p. 27; Connelly et al. 2000a, p. 974; Manville 2002, p. 7; Vander Haegen et al. 2002, p. 503). For example, within 1 year of construction of a 596-km (372.5-mi) transmission line in southern Idaho and Oregon, raptors and common ravens began nesting on the supporting poles (Steenhof et al. 1993, p. 275). Within 10 years of construction, 133 pairs of raptors and ravens were nesting along this stretch (Steenhof et al. 1993, p. 275). Raven counts have increased by approximately 200 percent along the Falcon-Gondor transmission line corridor in Nevada within 5 years of construction (Atamian et al. 2007, p. 2). Raven counts along this line have subsequently declined, but remain at higher rates than the first year following powerline construction (Blomberg et al. 2010, p. 34). Raptor occurrence rates along this transmission line have not changed since the line was constructed (Blomberg et al. 2010, p. 34). The increased abundance of raptors and corvids within occupied sage-grouse habitats can result in increased predation. Ellis (1985, p. 10) reported that golden eagle (Aquila chryrsaetos) predation on sage-grouse on leks increased from 26 to 73 percent of the total predation after completion of a transmission line within 200 meters (m) (220 yards (yd)) of an active sage-grouse lek in northeastern Utah. The lek was eventually abandoned, and Ellis (1985, p. 10) concluded that the presence of the powerline resulted in changes in sage-grouse dispersal patterns and caused fragmentation of the habitat.

With the exception of lek disturbance by common ravens, the effect of increased corvid abundance on sage-grouse populations occurring along the Falcon-Gondor line in central Nevada has not been determined. Lek disturbances appear correlated with corvid abundance along this transmission corridor (Sedinger, unpublished data). Nest success for sage-grouse along this line is low (average of 17.8 to 21.4 percent; Blomberg et al. 2010, p. 22) suggesting a potential impact of ravens on sage-grouse nest survival, although the authors acknowledge rates may be influenced by research activities. These nest survival rates are too low to sustain a stable population (Sedinger, unpublished data), but pre-construction nest survival rates were not presented. Preliminary results from this study suggest a top-down regulation of nest success (predators control prey populations), although the researchers have concluded that there is no influence of the Falcon-Gondor transmission line on nest success (Sedinger, unpublished data). Survival of nests along this transmission corridor was influenced by wildfire impacts and distance to roads (Blomberg et al. 2010, pp. 22-23).

Leks within 0.4 km (0.25 mi) of new powerlines constructed for coalbed methane development in the Powder River Basin of Wyoming had significantly lower growth rates, as measured by recruitment of new males onto the lek, compared to leks further from these lines; which was presumed to be the result of increased raptor predation (Braun et al. 2002, p. 10). Connelly et al. (2004, p. 7-26) estimated that the area potentially influenced by additional perches for corvids and raptors provided by powerlines is 32 to 40 percent of sage-grouse habitat based on the average foraging distance of these predators. The actual impact on the area would depend on corvid and raptor densities within the area, the amount of cover to reduce predation risk at sage-grouse nests, and other factors (see discussion in Factor C, below).

The perceived threat of predation may result in sage-grouse avoidance of powerlines (Blomberg et al. 2010, p. 4, and references therein), potentially resulting in functional fragmentation of sage-grouse habitats. Braun (1998, p. 146) found that use of otherwise suitable habitat by sage-grouse near powerlines increased as distance from the powerline increased for up to 600 m (660 yd) and based on that unpublished data, reported that the presence of powerlines may limit sage-grouse use within 1 km (0.6 mi) in otherwise suitable habitat. Similar results were recorded for other grouse species. Pruett et al. (2009, p. 6) found that Lesser and Greater prairie-chickens (Tympanuchus pallidicinctus and T. cupido, respectively) avoided otherwise suitable habitat near powerlines. Additionally, both species also crossed powerlines less often than nearby roads which suggests that powerlines are a particularly strong barrier to movement (Pruett et al. 2009, p. 6).

Perch deterrents are often installed on power poles to preclude perching by raptors and corvids. This practice was initially for the intent of minimizing raptor electrocution (Slater and Smith 2010, p. 1080). However, perch-deterrent devices are now increasingly used to discourage raptor and raven perching to minimize predation on sensitive prey species, including sage-grouse. The efficacy of these deterrent devices has only been minimally evaluated. Prather and Messmer 2010 (p.799) determined that the actual effectiveness of perch deterrents were limited by the structure of the power poles and the basic design and placement of deterrents. The authors concluded that the commercially available deterrents evaluated in their study were ineffective for the reasons stated above, and due to structural flaws with the deterrents themselves (Prather and Messmer 2010, p. 799). In contrast, Slater and Smith 2010 (p. 1086) found perching by raptors and ravens was reduced on poles equipped with perch deterrents. However, the deterrent devices did not completely exclude perching, and the authors suggested that deterrent devices lose some effectiveness after initial installation (Slater and Smith 2010, p. 1086). We found no study that linked the use of deterrents to resultant effects on sage-grouse survival.

Sage-grouse also may avoid powerlines as a result of the electromagnetic fields (Wisdom et al. 2011, p. 467). Electromagnetic fields have been demonstrated to alter the behavior, physiology, endocrine systems and immune function in birds, with negative consequences on reproduction and development (Fernie and Reynolds 2005, p. 135). Birds are diverse in their sensitivities to electromagnetic field exposures, with domestic chickens being very sensitive. Many raptor species are less affected (Fernie and Reynolds 2005, p. 135).

Linear corridors through sagebrush habitats can facilitate the spread of invasive species, such as Bromus tectorum (cheatgrass) (Gelbard and Belnap 2003, pp. 424-426; Knick et al. 2003, p. 620; Connelly et al. 2004, p. 1-2). However, we were unable to find any information regarding the amount of invasive species incursion in sage-grouse habitatas a result of powerline construction.

Section 368(a) of the Energy Policy Act of 2005 (42 U.S.C. 15926) directs Federal land management agencies to designate corridors on Federal land in 11 western States for oil, gas and hydrogen pipelines and electricity transmission and distribution facilities (energy transport corridors). The agencies completed a programmatic EIS (DOE et al. 2008, entire) to address the environmental impacts of corridors on Federal lands. The proposed action calls for designating more than 9,600 km (6,000 mi) with an average width of 1 km (0.6 mi) of energy corridors across the western United States (DOE et al. 2008, p. S-17). The designated corridors on Federal lands will tie in to corridors on private lands and lands in other governmental jurisdictions. Some of the areas proposed for designation are currently used for transmission. Federal lands newly incorporated into transportation or utility rights-of-way are mostly BLM lands in California (185 km, 115 mi), Colorado (97 km, 60 mi), Idaho (303 km, 188 mi), Montana (254 km, 158 mi), Nevada (810 km, 503 mi), Oregon (418 km, 260 mi), Washington (no additional land), Utah (356 km, 221 mi), and Wyoming (198 km, 123 mi) (DOE et al. 2008, p. S-18). The purpose of the corridor designation is to serve a role in expediting applications to construct or modify oil, gas, and hydrogen pipelines and electricity transmission and distribution. These designated areas will also likely facilitate the development of novel renewable and nonrenewable electricity generating facilities on public and private lands. Development of energy resources associated with the new transmission corridors could result in locally significant increases of powerlines. For example, up to 8,579 km (5,311 mi) of new powerlines are predicted for the development of the Powder River Basin coal-bed methane field in northeastern Wyoming (BLM 2003) in addition to the approximately 9,656 km (6,000 mi) already constructed in that area.

We know of at least twelve proposed transmission lines (230 kV or larger), portions of which will cross greater sage-grouse habitats (Gateway West, Gateway South, SWIP North, Mountain States Transmission Intertie, Montana Alberta Tie Project, High Plains Express, Hemingway to Captain Jack Transmission Line, and Canada/Pacific Northwest-Northern California, Southwest Intertie, Chinook, Overland Intertie, Zephyr/Northern Lights), affecting nearly the entire distribution of the species. Additionally, sage-grouse populations that are currently in relatively fragmented habitats (e.g. SW Montana and NE Idaho) are likely to be affected by the construction of these new transmission corridors. Sage-grouse could be impacted through a direct loss of habitat, human activity (especially during construction periods), increased predation, habitat deterioration through the introduction of nonnative plant species, and additional fragmentation of habitat.

Communication Towers

Within sage-grouse habitats, 9,510 new communication towers have been constructed within recent years (Connelly et al. 2004, p. 13-7). While millions of birds are killed annually in the United States through collisions with communication towers and their associated structures (e.g., guy wires, lights) (Shire et al. 2000, p. 5; Manville 2002, p. 10), most documented mortalities are of migratory songbirds. We were unable to determine if any sage-grouse mortalities occur as a result of collision with communication towers or their supporting structures, as most towers are not monitored and those that are lie outside the range of the species (Kerlinger 2000, p. 2; Shire et al. 2000 p. 19). Cellular towers have the potential to cause sage-grouse mortality via collisions, to influence movements through avoidance of a tall structure (Wisdom et al. 2011, p. 468), or to provide perches for corvids and raptors (Steenhof et al. 1993, p. 275; Connelly et al. 2004, p. 13-7).

In a comparison of sage-grouse locations in extirpated areas of their range (as determined by museum species and historical observations) and currently occupied habitats, the distance to cellular towers was nearly twice as far from grouse locations in currently occupied habitats than extirpated areas (Wisdom et al. 2011, p. 462). The results may have been influenced by location as many cellular towers are close to intensive human development. However, such associations with other indicators of development and cellular towers were low (Wisdom et al. 2011, p. 468). High levels of electromagnetic radiation within 500 m (547 yd) of all towers have been linked to decreased populations and reproductive performance of some bird and amphibian species (Wisdom et al. 2011, p. 468, and references therein). We do not know if greater sage-grouse are negatively impacted by electromagnetic radiation, or if their avoidance of these structures is a response to increased predation risk.

Fences

The effects of fencing on sage-grouse include direct mortality through collisions, creation of predator (raptor) and corvid perch sites, the potential creation of predator corridors along fences (particularly if a road is maintained next to the fence), incursion of exotic species along the fencing corridor, and habitat fragmentation (Call and Maser 1985, p. 22; Braun 1998, p. 145; Connelly et al. 2000a, p. 974; Beck et al. 2003, p. 211; Knick et al. 2003, p. 612; Connelly et al. 2004, p. 1-2). We found no information that quantitatively links these potential fencing impacts, with the exception of collisions, to sage-grouse persistence or habitat use.

Sage-grouse frequently fly low and fast across sagebrush flats, and fences can create a collision hazard (Call and Maser 1985, p. 22). Thirty-six carcasses of sage-grouse were found near Randolph, Utah, along a 3.2-km (2-mi) fence within 3 months of its construction (Call and Maser 1985, p. 22). Twenty-one incidents of mortality through fence collisions near Pinedale, Wyoming, were reported in 2003 to the BLM (Connelly et al. 2004, p. 13-12). A recent study in Wyoming confirmed 146 sage-grouse fence strike mortalities over a 31-month period along a 7.6-km (4.6-mi) stretch of 3-wire BLM range fence (Christiansen in litt. 2009). These studies suggest that fences constructed in or near important habitats (e.g. leks) may be an important source of mortality for some populations. Recent work in Idaho suggests that published fence collision rate estimates are likely underestimated (Stevens et al. in litt. 2010). However, the authors of this study cautioned that their initial results may be influenced by small sample sizes and variability in sampling (Stevens et al. in litt. 2010). This research project will continue.

Not all fences present the same mortality risk to sage-grouse. Mortality risk appears to be dependent on a combination of factors including design of fencing, landscape topography, and spatial relationship with seasonal habitats (Christiansen 2009, unpublished data). Although the effects of direct strike mortality on populations are not understood, fences are ubiquitous across the landscape. In many parts of the sage-grouse range (primarily Montana, Nevada, Oregon, Wyoming) fences exceed densities of more than 2 km/km2 (1.2 mi/0.4 mi2; Knick et al. 2011, p. 224). Fence collisions continue to be identified as a source of mortality for sage-grouse and we expect this source of mortality to continue into the foreseeable future. (Braun 1998, p. 145; Connelly et al. 2000a, p. 974; Oyler-McCance et al. 2001, p. 330; Connelly et al. 2004, p. 7-3).

Fence posts create perching places for raptors and corvids, which may increase their ability to prey on sage-grouse (Braun 1998, p. 145; Oyler-McCance et al. 2001, p. 330; Connelly et al. 2004, p. 13-12). We anticipate that the effect on sage-grouse populations through the creation of new raptor perches and predator corridors into sagebrush habitats is similar to that of powerlines discussed previously (Braun 1998, p. 145; Connelly et al. 2004, p. 7-3). Fences and their associated roads also facilitate the spread of invasive plant species that replace sagebrush plants upon which sage-grouse depend (Braun 1998, p. 145; Connelly et al. 2000a, p. 973; Gelbard and Belnap 2003, p. 421; Connelly et al. 2004, p. 7-3). Greater sage grouse avoidance of habitat adjacent to fences, presumably to minimize the risk of predation, effectively results in habitat fragmentation even if the actual habitat is not removed (Braun 1998, p. 145).

Over 51,000 km (31,690 mi) of fences were constructed on BLM lands supporting sage grouse populations between 1962 and 1997 (Connelly et al. 2000a, p. 974). More than 1,000 km (625 mi) of fences were constructed annually in sagebrush habitats from 1996 through 2002, mostly in Montana, Nevada, Oregon and Wyoming (Connelly et al. 2004, p. 7-34). We have been unable to locate any current data on new fence construction since that date. The Natural Resources Conservation Service (NRCS) has engaged in contracts with private landowners within the range of greater sage-grouse, removing or marking 290 km (180 mi) of fence in an effort to reduce the impact of this threat on sage-grouse (NRCS 2011, in litt.). NRCS estimates that this effort has cumulatively resulted in approximately 800 to 1,000 fewer fence collisions by greater sage-grouse (NRCS 2011, in litt.).

Roads

Interstate highways and major paved roads cover approximately 2, 500 km2 (965 mi2) or 0.1 percent of sagebrush habitats (Knick et al. 2011, p. 213), but are estimated to influence 851,044 km2 (328,590 mi2) or 41 percent of the sagebrush habitats that support sage-grouse. Additionally, secondary paved roads are heavily distributed throughout most of the sage-grouse range existing at densities of up to greater than 5 km/km2 (3.1 mi/mi2). Taken together, 95 percent of all sage-grouse habitats were within 2.5 km (1.5 mi) of a mapped road and almost no area of sagebrush was greater the 6.9 km (4.3 mi) from a mapped road (Knick et al. 2011, p. 213).

Impacts from roads may include direct habitat loss, direct mortality, barriers to migration corridors or seasonal habitats, facilitation of predators and spread of invasive vegetative species, and other indirect influences such as noise (Forman and Alexander 1998, pp. 207-231). Sage-grouse mortality resulting from collisions with vehicles does occur (Patterson 1952, p. 81), but mortalities are typically not monitored or recorded. Therefore, we are unable to determine the importance of this factor on sage-grouse populations. Data regarding how roads affect seasonal habitat availability for individual sage-grouse populations by creating barriers and the ability of greater sage-grouse to reach these areas were not available. Road development within Gunnison sage-grouse (*C. minimus*) habitats impeded movement of local populations between the resultant patches, with grouse road avoidance presumably being a behavioral means to limit exposure to predation (Oyler-McCance et al. 2001, p. 330).

Roads can provide corridors for predators to move into previously unoccupied areas. For some mammalian species, dispersal along roads has greatly increased their distribution (Forman and Alexander 1998, p. 212; Forman 2000, p. 33). Corvids also use linear features such as primary and secondary roads as travel routes, expanding their movements into previously unused regions (Knight and Kawashima 1993, p. 268; Connelly et al. 2004, p. 12-3; Bui et al. 2010, p. 74). Additionally, highway rest areas provide a source of food and perches for corvids and raptors, and facilitate their movements into surrounding areas (Connelly et al. 2004, p. 7-25). In an analysis of anthropogenic impacts, at least 58 percent of sagebrush habitats within the range of sage-grouse had a high or medium estimated presence of corvids (Connelly et al. 2004, p. 12-6). Corvids are important sage-grouse nest predators and in a study in Nevada were identified as responsible for more than 50 percent of nest predations in the study area (Coates 2007, pp. 26-30).

The presence of roads increases human access and resulting disturbance effects in remote areas (Forman and Alexander 1998, p. 221; Forman 2000, p. 35; Connelly et al. 2004, pp. 7-6 to 7-25). Increases in legal and illegal hunting activities resulting from the use of roads within sagebrush habitats have been documented (Hornaday 1916, p. 183; Patterson 1952, p. vi). However, the actual current effect of these increased activities on sage-grouse populations has not been determined. Roads also may facilitate access for rangeland habitat treatments, such as disking or mowing (Connelly et al. 2004, p. 7-25), resulting in subsequent direct habitat losses. New roads are being constructed to support development activities within the greater sage-grouse extant range. In the Powder River Basin of Wyoming, there are up to 28,572 km (17,754 mi) of roads to support coalbed methane development (BLM 2003).

The expansion of road networks contributes to exotic plant invasions via introduced road fill, vehicle transport, and road maintenance activities (Forman and Alexander 1998, p. 210; Forman 2000, p. 32; Gelbard and Belnap 2003, p. 426; Knick et al. 2003, p. 619; Connelly et al. 2004, p. 7-25). Invasive species are not limited to roadsides, but also encroach into surrounding habitats (Forman and Alexander 1998, p. 210; Forman 2000, p. 33; Gelbard and Belnap 2003, p. 427). Improving unpaved four-wheel drive roads to paved roads results in increased cover of exotic plant species within the interior of adjacent plant communities (Gelbard and Belnap 2003, p. 426). This effect was associated with road construction and maintenance activities and vehicle traffic, and not with differences in site characteristics. The incursion of exotic plants into native sagebrush systems can negatively affect greater sage-grouse through habitat losses and conversions (see further discussion in Invasives below).

Additional indirect effects of roads may result from birds’ behavioral avoidance of road areas because of noise, visual disturbance, pollutants, and predators moving along a road. The absence of vegetation in arid and semiarid regions that may buffer these impacts further exacerbates the problem (Suter 1978, p. 6). Male sage-grouse lek attendance was shown to decline within 3 km (1.9 mi) of a methane well or haul road with traffic volume exceeding one vehicle per day (Holloran 2005, p. 40). Male sage-grouse depend on acoustical signals to attract females to leks (Gibson and Bradbury 1985, p. 82; Gratson 1993, p. 692). If noise interferes with mating displays, and thereby female attendance, younger males will not be drawn to the lek and eventually leks will become inactive (Amstrup and Phillips 1977, p. 26; Braun 1986, pp. 229-230).

Dust from roads and exposed roadsides can damage vegetation through interference with photosynthetic activities. The actual amount of potential damage depends on winds, wind direction, the type of surrounding vegetation and topography (Forman and Alexander 1998, p. 217). Chemicals used for road maintenance, particularly in areas with snowy or icy precipitation, can affect the composition of roadside vegetation (Forman and Alexander 1998, p. 219). We were unable to find any data relating these potential effects directly to impacts on sage-grouse population parameters.

In Wyoming, sage-grouse hens that bred on leks within 3 km (1.9 mi) of roads associated with oil and gas development traveled twice as far to nest as did hens bred on leks greater than 3 km (1.9 mi) from roads. Nest initiation rates for hens bred on leks close to roads also were lower (65 versus 89 percent) affecting population recruitment (33 versus 44 percent) (Lyon 2000, p. 33; Lyon and Anderson 2003, pp. 489-490). Their results were similar to those reported by Blomberg et al. 2010 (p. 23), who reported that nests near roads (within 300 m, (948 ft)) had lower survival rates. Lyon and Anderson (2003, p. 490) suggested that roads may be the primary impact of oil and gas development to sage-grouse, due to their persistence and continued use even after drilling and production have ceased. Braun et al. (2002, p. 5) suggested that daily vehicular traffic along road networks for oil wells can impact sage-grouse breeding activities based on lek abandonment patterns.

Connelly et al. (2004, p. 13-12) found that no leks within 2 km (1.25 mi) of interstate 80 and only 9 leks were found between 2 and 4 km (1.25 and 2.5 mi) along this same highway. The number of active leks increased with increasing distance from the interstate. Lek persistence and activity relative to distance from the interstate also were measured. The distance of a lek from the interstate was a significant predictor of lek activity, with leks further from the interstate more likely to be active. An analysis of long-term changes in populations between 1970 and 2003 showed that leks closest (within 7.5 km (4.7 mi)) to the interstate declined at a greater rate than those further away (Connelly et al. 2004, p. 13-13). Extirpated sage-grouse range was 60 percent closer to highways (Wisdom et al. 2011, p. 467). What is not clear from these studies is what specific factor relative to roads (e.g., noise, changes in vegetation, etc.) sage-grouse are responding to. Connelly et al. (2004, p. 13-13) caution that they have not included other potential sources of indirect disturbance (e.g., powerlines) in their analyses.

Aldridge et al. (2008, p. 992) did not find road density to be an important factor affecting sage-grouse persistence or rangewide patterns in sage-grouse extirpation. However, the authors did not consider the intensity of human use of roads in their modeling efforts. They also indicated that their analyses may have been influenced by inaccuracies in spatial road data sets, particularly for secondary roads (Aldridge et al. 2008, p. 992). However, Wisdom et al. (2011, p. 467) found that extirpated range has a 25 percent higher density of roads than occupied range. Wisdom et al.'s (2011) rangewide analysis supports the findings of numerous local studies showing that roads can have both direct and indirect impacts on sage-grouse distribution and individual fitness (e.g., Lyon and Anderson 2003, Aldridge and Boyce 2007).

Railroads

Railroads presumably have the same potential impacts to sage-grouse as do roads because they create linear corridors within sagebrush habitats. Railways and the cattle they transport were primarily responsible for the initial spread of Bromus tectorum in the intermountain region (Connelly et al. 2004, p. 7-25). B. tectorum, an exotic species that is unsuitable as sage-grouse habitat, readily invaded the disturbed soils adjacent to railroads. Fires created by trains facilitated the spread of B. tectorum into adjacent areas. Knick et al. (2011, p. 213) found that railroads cover 487 km2 (188 mi2) or less than 0.1 percent of sagebrush habitats that support sage-grouse, but they estimated railroads could influence 10 percent of that area. Avian collisions with trains occur, although no estimates of mortality rates are documented in the literature (Erickson et al. 2001, p. 8).

Summary of Infrastructure as a Source of Fragmentation of Sagebrush Habitats

Infrastructure such as powerlines, roads, communication towers and fences continue to fragment sage-grouse habitat. Past and current trends lead us to believe this source of fragmentation will increase into the future. Fragmentation of sagebrush habitats through a variety of mechanisms including those listed above has been cited as a primary cause of the decline of sage-grouse populations (Patterson 1952, pp. 192-193; Connelly and Braun 1997, p. 4; Braun 1998, p. 140; Johnson and Braun 1999, p. 78; Connelly et al. 2000a, p. 975; Miller and Eddleman 2000, p. 1; Schroeder and Baydack 2001, p. 29; Johnsgard 2002, p. 108; Aldridge and Brigham 2003, p. 25; Beck et al. 2003, p. 203; Pedersen et al. 2003, pp. 23-24; Connelly et al. 2004, p. 4-15; Schroeder et al. 2004, p. 368; Leu and Hanser 2011, p. 267). The negative effects of habitat fragmentation on sage-grouse are diverse and include reduced lek persistence, lek attendance, winter habitat use, recruitment, yearling annual survival, and female nest site choice (Holloran 2005, p. 49; Aldridge and Boyce 2007, pp. 517-523; Walker et al. 2007a, pp. 2651-2652; Doherty et al. 2008, p. 194). Since fragmentation is associated with most anthropogenic activities, the effects are ubiquitous across the species range (Knick et al. 2011, p. 203). We agree with the assessment that habitat fragmentation is a primary cause of sage-grouse decline and in some areas has already led to population extirpation. We also conclude that habitat fragmentation caused by infrastructure will continue into the foreseeable future and will continue to threaten the persistence of greater sage-grouse.

Fire

Many of the native vegetative species of the sagebrush-steppe ecosystem are killed by wildfires, and recovery requires many years. As a result of this loss of habitat, fire has been identified as a primary factor associated with greater sage-grouse population declines (Hulet 1983, in Connelly et al. 2000a, p. 973; Crowley and Connelly 1996, in Connelly et al. 2000c, p. 94; Connelly and Braun 1997, p. 232; Connelly et al. 2000a, p. 973; Connelly et al. 2000c, p. 93; Miller and Eddlemen 2000, p. 24; Johnson et al., 2011, p. 448; Knick and Hanser, 2011, pp. 399-400). In nesting and wintering sites, fire causes direct loss of habitat due to reduced cover and forage (Call and Maser 1985, p. 17; Rowland and Wisdom 2002, p. 28). Big sagebrush species, the most important and widespread group of sagebrush, are killed by fire and require decades to recover (Rhodes et al. 2010, p. 755, and references therein). Nelle et al. (2000, p. 586) and Beck et al. (2009, p. 400) reported nesting habitat loss from fire, creating a long-term negative impact that will require 25 to 150 years of sagebrush re-growth before sufficient canopy cover becomes available for nesting birds. Prior to recovery, burned sites are of limited to no use to sage-grouse (Fischer et al. 1996, p. 196; Connelly et al. 2000c, p. 90; Nelle et al. 2000, p. 588; Beck et al. 2009, p. 400; Hess and Beck 2010, p. 52). Therefore, fire results in direct, long-term habitat loss.

Negative effects of fire on sage-grouse populations have been documented. For example, in a study in southeastern Idaho, sage-grouse populations were generally declining but declines were more severe in post-fire years (Connelly et al. 2000c, p. 93). Male survival and nest success were negatively influenced by wildfires in central Nevada (Blomberg et al. 2010, p. 25). Fire had a negative effect on lek trends in the Snake River Plain (MZ IV) and Southern Great Basin (MZ III) (Johnson et al. 2011, p.424). Hulet (1983, in Connelly et al. 2000a, p. 973) documented the loss of leks from fire. Fire within 54 km (33.6 mi) of a lek is one of two primary factors in predicting lek extirpation (Knick and Hanser 2011, p. 395). Small increases in the amount of burned habitat surrounding a lek had a large influence on the probability of lek abandonment (Hess and Beck 2010, p. 123; Knick and Hanser, 2011, p. 395). Several recent studies have demonstrated that sagebrush area is one of the best landscape predictors of greater sage-grouse persistence (Aldridge et al. 2008, p. 987; Doherty et al. 2008, p. 191; Wisdom et al., 2011, p. 461), and therefore any loss of sagebrush habitat will negatively impact the ability of grouse to survive in the affected area (Erickson 2011, p. 77). Fischer et al. (1997, p. 89) concluded that habitat fragmentation caused by fire may influence distribution or migratory patterns in sage-grouse. While there may be limited instances where burned habitat is beneficial, these gains are lost if sagebrush habitat is not readily available (Woodward 2006, p. 65). Byrne (2002, p. 27) reported avoidance of burned habitats by nesting, brooding, and broodless females.

Herbaceous understory vegetation plays a critical role throughout the breeding season as a source of forage and cover for sage-grouse females and chicks. The response of herbaceous understory vegetation to fire varies with differences in species composition, pre-burn site condition, fire intensity, and pre- and post-fire patterns of precipitation. In general, when not considering the synergistic effects of invasive species, any short-term flush of understory grasses and forbs is lost after only a few years and little difference is apparent between burned and unburned sites (Cook et al. 1994, p. 298; Fischer et al. 1996, p. 196; Crawford 1999, p. 7; Wrobleski 1999, p. 31; Nelle et al. 2000, p. 588; Paysen et al. 2000, p. 154; Wambolt et al. 2001, p. 250; Hess and Beck 2010, p. 53; Erickson 2011, p. 32). There was no increase in the nutritional quality of sage-grouse food forbs following prescribed burning in north-central Wyoming (Hess and Beck 2010, p. 49; Rhodes et al. 2010, p. 761). An additional concern is the incursion of annual brome species into burned areas. Brome species do not provide habitat for sage-grouse and contribute to the accelerating fire cycle in sagebrush (see discussion below). Higher annual brome canopy covers were recorded in prescribed burns up to 19 years old (Hess and Beck 2010, p. 53).

In addition to altering plant community structure, fires can influence invertebrate food sources (Schroeder et al. 1999, p. 5) that are an essential component of juvenile greater sage-grouse diets, especially in the first three weeks of life (Johnson and Boyce 1991, p. 90). The effect of fire on insect populations varies due to a host of environmental factors. Crawford and Davis (2002, p. 56) reported that the abundance of arthropods did not decline following wildfire. Pyle (1992, p. 14) reported no apparent effect of prescribed burning to beetles. However, Fischer et al. (1996, p. 197) found that the abundance of insects was significantly lower 2-3 years post-burn. Additionally, grasshopper abundance declined 60 percent in burned plots versus unburned plots 1 year post-burn, but this difference disappeared the second year (Bock and Bock 1991, p. 165). Conversely, Nelle et al. (2000, p. 589) reported the abundance of beetles and ants was significantly greater in 1-year old burns, but returned to pre-burn levels by years 3 to 5. Hess and Beck 2010 (p. 52) found no difference in insect weights between prescribed burns and reference sites in north-central Wyoming. The specific magnitude and duration of the effects of fire on insect communities is still uncertain, as is the effect any changes may have on greater sage-grouse populations.

The few studies that have suggested fire may be beneficial for greater sage-grouse were primarily conducted in mesic areas used for brood-rearing (Klebenow 1970, p. 399; Pyle and Crawford 1996, p. 323; Gates 1983, in Connelly et al. 2000c, p. 90; Sime 1991, in Connelly et al. 2000a, p. 972). In this habitat, small fires may maintain a suitable habitat mosaic by reducing shrub encroachment and encouraging understory growth. However, without nearby sagebrush cover, the utility of these sites is questionable. For example, Slater (2003, p. 63) reported that sage-grouse using burned areas were rarely found more than 60 m (200 ft) from the edge of the burn and may preferentially use the burned and unburned edge habitat. Both Connelly et al. (2000c, p. 90) and Fischer et al. (1996, p. 196) found that prescribed burns did not improve brood rearing habitat in Wyoming big sagebrush, as forbs did not increase and insect populations declined. Hence, fires in these locations may negatively affect brood rearing habitat rather than improve it (Connelly and Braun 1997, p. 11; Rhodes et al. 2010, p. 763). Any potential improvement resulting from increased forb production within prescribed burn locations were completely negated by the loss of shrub cover (Erickson 2011, p. 78). Use of winter habitats was also reduced following prescribed fires (Erickson 2011, p. 71).

The nature of historical fire patterns in sagebrush communities, particularly in Artemisia tridentata var. wyomingensis, is not well understood and a high degree of variability likely occurred (Miller and Eddleman 2000, p. 16; Zouhar et al. 2008, p. 154; Baker 2011, p. 198). However, as inferred from several lines of reasoning, fire in sagebrush systems was historically infrequent (Baker 2011, p. 196). This conclusion is supported by the fact that most sagebrush species have not developed evolutionary adaptations such as re-sprouting and heat-stimulated seed germination found in other shrub dominated systems, like chaparral, exposed to relatively frequent fire events. Baker (2011, p. 197) suggests natural fire regimes and landscapes were typically shaped by a few infrequent large fire events that occurred at intervals approaching the historical fire rotation (50 to 350 years – see discussion below). The researcher concludes that the historical sagebrush systems likely consisted of extensive sagebrush habitat dotted by small areas of grassland and that this condition was maintained by long interludes of numerous small fires, accounting for little burned area, punctuated by large fire events that consumed large expanses. In general, fire extensively reduces sagebrush within burned areas, and big sagebrush varieties(the most widespread species of sagebrush) can take up to 150 years to re-establish an area (Braun 1998, p. 147; Cooper et al. 2007, p. 13; Lesica et al. 2007, p. 264; Hess and Beck 2010, p. 125; Baker, 2011, p. 196).

Fire rotation, or the average amount of time it takes to burn once through a particular landscape, is difficult to quantify in large sagebrush expanses. Because sagebrush is killed by fire, it does not record evidence of prior burns (i.e., fire scars) as do forested systems. As a result, a clear picture of the complex spatial and temporal pattern of historical fire regimes in most sagebrush communities is not available. Widely variable estimates of historical fire rotation have been described in the literature. Depending on the species of sagebrush and other site-specific characteristics, fire return intervals from 10 to well over 300 years have been reported (McArthur 1994, p. 347; Peters and Bunting 1994, p. 33; Miller and Rose 1999, p. 556; Kilpatrick 2000, p. 1; Frost 1998, in Connelly et al. 2004, p. 7-4; Zouhar et al. 2008, p. 154; Baker 2011, p. 196). In general, mean fire return intervals in low lying, xeric big sagebrush communities range from over 100 to 350 years, and return intervals decrease from 50 to over 200 years in more mesic areas, at higher elevations, during wetter climatic periods, and in locations associated with grasslands (Baker 2006, p. 181; Mensing et al. 2006, p. 75;

Baker, 2011, p. 196; Miller et al., 2011, p. 166).

The invasion of exotic annual grasses, such as Bromus tectorum and Taeniatherum asperum (medusahead), increases fire frequency within the sagebrush ecosystem (Zouhar et al. 2008, p. 41; Miller et al. 2011, p. 167). B. tectorum readily invades sagebrush communities, especially disturbed sites, and changes historical fire patterns by providing an abundant and easily ignitable fuel source that facilitates fire spread. While sagebrush is killed by fire and is slow to reestablish, B. tectorum recovers within 1 to 2 years of a fire event (Young and Evans 1978, p. 285). This annual recovery leads to a readily burnable fuel source and ultimately a reoccurring fire cycle that prevents sagebrush reestablishment (Eiswerth et al. 2009, p. 1324). In the Snake River Plain (MZ IV), for example, fire rotation due to B. tectorum establishment is now as low as 3-5 years (Whisenant 1990, p. 4). It is difficult and usually ineffective to restore an area to sagebrush after annual grasses become established (Paysen et al. 2000, p. 154; Connelly et al. 2004, pp. 7-44 to 7-50; Pyke, 2011, pp. 539-540). Habitat loss from fire and the subsequent invasion by nonnative annual grasses have negatively affected sage-grouse populations in some locations (Connelly et al. 2000c, p. 93).

Bromus tectorum invasion has significantly increased fire occurrence in the Snake River Plain and Northern Great Basin since the 1960s (Miller et al., 2011, p. 170) and in northern Nevada and eastern Oregon since 1980 (MZs IV and V). The extensive distribution and highly invasive nature of B. tectorum poses substantial increased risk of fire and permanent loss of sagebrush habitat, as areas disturbed by fire are highly susceptible to further invasion and ultimately habitat conversion to an altered community state. For example, risk of fire increases from approximately 46 to 100 percent when ground cover of B. tectorum increases from 12 to 45 percent or more (Link et al. 2006, p. 116). In the Great Basin Ecoregion (defined as east-central California, most of Nevada, and western Utah, MZs IV and V), approximately 58 percent of sagebrush habitats are at moderate to high risk of B. tectorum invasion during the next 30 years (Suring et al. 2005, p. 138). The BLM estimated that approximately 11.9 million ha (29 million ac) of public lands in the western distribution of the greater sage-grouse (Washington, Oregon, Idaho, Nevada, Utah) were infested with weeds as of 2000 (BLM 2007a, p. 3-28). The most dominant invasive plants consist of grasses in the Bromus genus, which represent nearly 70 percent of the total infested area (BLM 2007a, p. 3-28).

Conifer woodlands have expanded into sagebrush ecosystems over the last century (Miller et al. 2011, p. 167). Woodlands can encroach into sagebrush communities when the interval between fires becomes long enough for seedlings to establish and trees to mature and dominate a site (Miller et al. 2011, p. 167). However, historical fire rotation appears to have been sufficiently long to allow woodland invasion, and yet extensive stands of mature sagebrush were evident during settlement times (Vale 1975, p. 33; Baker, 2011, p. 186). This suggests that causes other than active fire suppression must largely explain recent tree invasions into sagebrush habitats (Baker 2011, p. 196, 200). Baker (2011, p. 200) and Miller et al. (2011, p. 169) offer a suite of causes, acting in concert with fire exclusion that may better explain the dramatic expansion of conifer woodlands over the last century. These causes include alterations due to domestic livestock grazing (such as reduced competition from native grasses and forbs and facilitation of tree regeneration by increased shrub cover and enhanced seed dispersal), climatic fluctuations favorable to tree regeneration, enhanced tree growth due to increased water use efficiency associated with carbon dioxide fertilization, and recovery from past disturbance (both natural and anthropogenic). Regardless of the cause of conifer woodland encroachment, the rate of expansion is increasing and is resulting in the loss and fragmentation of sagebrush habitats (see discussion in Pinyon-juniper section below).

Between 1980 and 2007, the number of fires and total area burned increased in all MZs across the greater sage-grouse's range except the Snake River Plain (MZ IV) (Miller et al., 2011, p. 169). Additionally, average fire size increased in the Southern Great Basin (MZ III) during this same period. However, predicting the amount of habitat that will burn during an "average fire" year is difficult due to the highly variable nature of fire seasons. For example, the approximate area burned on or adjacent to BLM-managed lands varied from 140,000 ha (346,000 ac) in 1998 to a 6-fold increase in 1999 (814,200 ha; 2 million ac) returning back down to approximately 1998 levels in 2002 (157,700 ha; 384,743 ac) before rising again 10-fold in 2006 (1.4 million ha; 3.5 million ac) (Miller et al., 2011, p. 170).

From 1980 to 2007, wildfires burned approximately 8.7 million ha (21.5 million ac) of sagebrush, or approximately 18 percent of the estimated 47.5 million ha (117.4 million ac) of sagebrush habitat within the MZs (Baker, 2011, p. 193). Additionally, the total acreage burned since 1980 has primarily increased (Miller et al., 2011, p. 170). Although fire alters sagebrush habitats throughout the greater sage-grouse's range, fire disproportionately affects the Great Basin (Baker, 2011, p. 198) (i.e., Utah, Nevada, Idaho, and eastern Oregon; MZ III, IV, and V) and will likely influence the persistence of greater sage-grouse populations in the area. In these three MZs combined, nearly 27 percent of sagebrush habitat has burned since 1980 (Baker, 2011, p. 193). A primary reason for this disproportionate influence in this region is due to the presence, and subsequent susceptibility of burned sites to invasion by exotic annual grasses.

According to one review, range fires destroyed 30 to 40 percent of sage-grouse habitat in southern Idaho (MZ IV) in a 5-year period (1997-2001) (Signe Sather-Blair, BLM, in Healy 2001). This amount included about 202,000 ha (500,000 ac) which burned between 1999 and 2001, significantly altering the largest remaining contiguous patch of sagebrush in the State (Signe Sather-Blair, BLM, in Healy 2001). Between 2003 and 2007, Idaho lost an additional 267,000 ha (660,000 ac) of sage-grouse habitat, or approximately 7 percent of the total estimated remaining habitat in the State. Over nine fire seasons in Nevada (1999-2007), about 1 million ha (2.5 million ac) of sagebrush were burned, representing approximately 12 percent of the State's extant sagebrush habitat (Espinosa and Phenix 2008, p. 3). Most of these fires occurred in northeast Nevada (MZ IV) within quality habitat that has traditionally supported high densities of sage-grouse, which also is highly susceptible to Bromus tectorum invasion. Since the publication of our March 2010 status review, a minimal estimate of an additional 53,977 ha (133,381 ac) of sage-grouse habitats were burned by wildfire (CDOW 2011, in litt.; IDFG 2011, in litt.; WGFD 2011, in litt.). Idaho was most affected with 50631 ha (125,111 ac) of key sage-grouse habitats burned (IDFG 2011, in litt.). The BLM reported 26,375 ha (65,173 ac) of wildfires burned on BLM lands in 2010, but suggests this value may be an overestimate of actual sage-grouse habitats affected (BLM 2011, in litt.). With the data received we could not discern how the estimates provided by the States and BLM overlapped, if at all. Aggressive rehabilitation efforts have been initiated on most of these burns. Other wildfires occurred in this interim, but quantified acreages of sage-grouse habitats were not provided.

Baker (2011, pp. 198-199) concludes that increased fire rotations since 1980 are presumably outside the historic range of variability and far shorter in floristic regions where Wyoming big sagebrush is common (Baker 2011, pp. 198-199). This analysis included MZs III, IV, V, and VI, all of which have extensive Bromus tectorum invasions.

In addition to wildfire, land managers are using prescribed fire as well as mechanical and chemical treatments to obtain desired management objectives for a variety of wildlife species and domestic ungulates in sagebrush habitats throughout the range of the greater sage-grouse. While the efficacy of treatments in sagebrush habitats to enhance sage-grouse populations is questionable (Peterson 1970, p. 154; Swensen et al. 1987, p. 128; Connelly et al. 2000c, p. 94; Nelle et al. 2000, p. 590; WAFWA 2009, p. 12; Hess and Beck 2010, p.54; Rhodes et al. 2010, p.763;Erickson 2011, p. 77; Connelly et al. in press c, p. 8), as with wildland fire, an immediate and potentially long-term result of these management practices is the loss of habitat (Beck et al. 2009, p. 400).

Over 370,000 ha (914,000 ac) of public lands were treated with prescribed fire to address management objectives for many different species between 1997 and 2006, mostly in Oregon and Idaho, and an additional 124,200 ha (306,900 ac) were treated with mechanical means over this same time period, primarily in Utah and Nevada (Knick et al. 2011, p. 224). However, these acreages represent all habitat types and thus over-estimate negative impacts to greater sage-grouse. Quantifying the amount of sagebrush-specific habitat treatments is difficult due to the fact that centralized reporting is not typically categorized by habitat. However, agencies under the Department of the Interior (DOI) report species of special interest, including greater sage-grouse, that may occur in proximity to a prescribed treatment. Between 2003 and 2008, approximately 133,500 ha (330,000 ac) of greater sage-grouse habitat have been burned by land managers within the DOI or approximately 22,000 ha (55,000 ac) annually. This acreage does not reflect lands burned by agencies under the USDA (e.g., USFS). Although much of the land under USFS jurisdiction lies outside greater sage-grouse range, this agency manages approximately 8 percent of sagebrush habitats. We are aware of prescribed burns in sage-grouse habitats conducted on BLM lands in the summer of 2010 in central Wyoming, but the acreages affected were not provided. Ultimately, the amount of sagebrush habitat treated by land managers appears to represent a relatively minor loss when compared to loss incurred by wildfire. However, in light of the significant habitat loss due to wildfire, and the preponderance of evidence that suggests these treatments are not beneficial to sage-grouse, the rationale for using such treatments to improve sage-grouse habitat deserves further scrutiny.

Sagebrush recovery rates from fire are highly variable, and precise estimates are often hampered by limited data from older burns. Factors contributing to the rate of shrub recovery include the amount of and distance from unburned habitat, abundance and viability of seed in soil seed bank (depending on species, sagebrush seeds are typically viable for one to three seasons), rate of seed dispersal, and pre- and post-fire weather, which influences seedling germination and establishment (Young and Evans 1989, p. 204; Maier et al. 2001, p. 701; Ziegenhagen and Miller 2009, p. 201). Based on a review of existing literature, Baker (2011, pp. 194-195) reports that full recovery to pre-burn conditions in Artemisia tridentata ssp. vaseyana communities ranges between 25 and 100 years and in A. t. ssp. wyomingensis communities between 50 and 120 years. However, the researcher cautions that data pertaining to the latter community is sparse. What is known is that by 25 years post-fire, A. t. ssp. wyomingensis typically has less than 5 percent pre-fire canopy cover (Baker 2011, p. 195).

A variety of techniques have been employed to restore sagebrush communities following a fire event (Cadwell et al. 1996, p. 143; Quinney et al. 1996, p. 157; Livingston 1998, p. 41). The extent and efficacy of restoration efforts is variable and complicated by limitations in capacity (personnel, equipment, funding, seed availability, and limited seeding window), incomplete knowledge of appropriate methods, invasive plant species, and abiotic factors, such as weather, that are largely outside the control of land managers (Hemstrom et al. 2002, pp. 1250-1251; Pyke, 2011, p. 544). While post-fire rehabilitation efforts have benefited from additional resources in recent years, resulting in an increase of treated acres from 28,100 ha (69,436 ac) in 1997 to 1.6 million ha (3.9 million ac) in 2002 (Connelly et al. 2004, p. 7-35), acreage treated annually remains far outpaced by acreage burned. For example, of the more than 1 million ha (2.5 million ac) of sage-grouse habitat burned during the 2006 and 2007 fire seasons on BLM-managed lands, about 40 percent or 384,000 ha (950,000 ac) had some form of active post-fire restoration such as reseeding. More specifically, Eiswerth et al. (2009, p. 1321) report that over the past 20 years within the BLM’s Winnemucca District in Nevada, approximately 12 percent of burned areas have been actively reseeded.

The main purpose of the Burned Area Emergency Stabilization and Rehabilitation program (BLM 2007b, pp. 1-2), designed to rehabilitate areas following fire, is to stabilize soils and maintain site productivity for livestock forage rather than to regain site suitability for wildlife (Pyke, 2011, p. 542). Consequently, in areas that experience active post-fire restoration efforts, an emphasis is often placed on introduced grasses that establish quickly. Only recently has a modest increase in the use of native species for burned area rehabilitation been reported (Richards et al. 1998, p. 630; Pyke, 2011, p. 542). Further complicating our understanding of the effectiveness of these treatments is that most managers do not keep track of monitoring data in a routine or systematic fashion (GAO 2003, p. 5). Assuming complete success of restoration efforts on targeted areas, however unlikely, the return of a shrub dominated community will still require several decades, and landscape restoration may require centuries or longer (Knick 1999, p. 55; Hemstrom et al. 2002, p. 1252). Even longer periods may be required for greater sage-grouse to use recovered or restored landscapes (Knick et al., 2011, p. 251). as sage-grouse are slow to recolonize burned areas even if structural features of the shrub community may have recovered (Knick et al., 2011, p. 233).

The loss of habitat due to wildland fire is anticipated to increase due to the intensifying synergistic interactions among fire, people, invasive species, and climate change (Miller et al., 2011, p. 183). The recent past- and present-day fire regimes across the greater sage-grouse distribution have changed with a demonstrated increase in fire in the more arid Wyoming big sagebrush communities and a decrease across many mountain big sagebrush communities. Both scenarios of altered fire regimes have caused significant losses to greater sage-grouse habitat through facilitating conifer expansion at high-elevation interfaces and exotic weed encroachment at lower elevations (Miller et al., 2011, p. 183). Predicted changes in temperature, precipitation and carbon dioxide are all anticipated to influence vegetation dynamics and alter fire patterns resulting in the increasing loss and conversion of sagebrush habitats (Neilson et al. 2005, p. 157). Further, many climate scientists suggest that in addition to the predicted change in climate toward a warmer and generally wetter Great Basin, variability of interannual and interdecadal wet-dry cycles will increase and likely act in concert with fire, disease, and invasive species to further stress the sagebrush ecosystem (Neilson et al. 2005, p. 152). The anticipated increase in suitable conditions for wildland fire will likely further interact with people and infrastucture. Human-caused fires have reportedly increased and been shown to be correlated with road presence (Miller et al., 2011. p. 171). Given the popularity of off-highway vehicles (OHV) and the ready access to lands in the Great Basin, the increasing trend in both fire ignitions by people and loss of habitat will likely continue.

In addition to loss of habitat and its influence on greater sage-grouse population persistence, fire contributes to fragmentation and isolation of populations, resulting in a higher probability of extirpation in disjunct areas (Knick and Hanser, 2011, p. 395; Wisdom et al., 2011, p. 465). Knick and Hanser (2011, p. 404) suggest extinction is currently more probable than colonization for many great sage-grouse populations because of their low abundance and isolation coupled with fire and human influence. As areas become isolated through disturbances such as fire, populations are exposed to additional stressors and persistence may be hampered by the limited ability of individuals to disperse into areas that are otherwise not self-sustaining. Thus, while direct loss of habitat due to fire has been shown to be a significant factor associated with population persistence, the indirect effect posed by loss of connectivity among populations may greatly expand the influence of this threat beyond the physical fire perimeter.

Summary of Fire

Fire is one of the primary factors linked to population declines of greater sage-grouse because of the resulting long-term loss of sagebrush and conversion to monocultures of exotic grasses (Connelly and Braun 1997, p. 7; Johnson et al., 2011, pp. 447-448; Knick and Hanser, 2011, p. 404). Loss of sagebrush habitat due to wildfire has been increasing in western areas of the greater sage-grouse range for the past three decades. The change in fire frequency has been strongly influenced by the presence of exotic annual grasses and significantly deviates from extrapolated historical regimes. Restoration of sagebrush communities is challenging, requires many years, and may, in fact, never be achieved in the presence of invasive grass species. Greater sage-grouse are slow to recolonize burned areas even if structural features of the shrub community may have recovered (Knick et al., 2011, p. 233). While it is not currently possible to predict the extent or location of future fire events, the best scientific and commercial information available indicates that fire frequency is likely to increase in the foreseeable future due to increases in cover of Bromus tectorum and the projected effects of climate change (see Invasive plants (annual grasses and other noxious weeds), below, and also Climate Change, below).

An analysis of previously extirpated sage-grouse habitats has shown that the extent and abundance of sagebrush habitats, proximity to burned habitat, and degree of connectivity among sage-grouse groups strongly affects persistence (Aldridge et al. 2008, p. 987; Knick and Hanser, 2011, p. 404; Wisdom et al., 2011, pp. 462-463). The loss of habitat caused by fire and the functional barrier burned habitat can pose to movement and dispersal compounds the influence this stressor can have on populations and population dynamics. Barring alterations to the current fire pattern, as well the difficulties associated with restoration, the concerns presented by this threat will continue and likely strongly influence persistence of the greater sage-grouse, especially in the western half of its range within the foreseeable future.

<u>Invasive plants</u>

Invasive plants (any nonnative plant that negatively impacts sage-grouse habitat, including annual grasses and other noxious weeds) alter plant community structure and composition, productivity, nutrient cycling, and hydrology (Vitousek 1990, p. 7) and may cause declines in native plant populations through competitive exclusion and niche displacement, among other mechanisms (Mooney and Cleland 2001, p. 5446). Invasive plants reduce and, in cases where monocultures occur, eliminate vegetation that sage-grouse use for food and cover. Invasives do not provide quality sage-grouse habitat. Sage-grouse depend on a variety of native forbs and the insects associated with them for chick survival, and sagebrush, which is used exclusively throughout the winter for food and cover. Invasives impact the entire range of sage-grouse, although not all invasive species are distributed across the entire range. Areas at high risk for invasion are distributed throughout the range, but are especially concentrated in eastern Washington (MZ VI), southern Idaho (MZ IV), central Utah (MZ III), and northeast Montana (MZ I) (Leu et al. 2008, pp. 1119-1139).

Along with replacing or removing vegetation essential to sage-grouse, invasives fragment existing sage-grouse habitat. They can create long-term changes in ecosystem processes, such as fire-cycles and other disturbance regimes that persist even after an invasive plant is removed (Zouhar et al. 2008, p. 33). A variety of nonnative annuals and perennials are invasive to sagebrush ecosystems (Connelly et al. 2004, pp. 7-107 and 7-108; Zouhar et al. 2008, p 144). Bromus tectorum is considered most invasive in Artemisia tridentata ssp. wyomingensis communities, while Taeniatherum asperum (medusahead) fills a similar niche in more mesic communities with heavier clay soils (Connelly et al. 2004, p. 5-9). Some other problematic rangeland weeds include Euphorbia esula (leafy spurge), Centaurea solstitialis (yellow starthistle), T. caput-medusae (medusahead rye) Centaurea maculosa (spotted knapweed), Centaurea diffusa (diffuse knapweed), and a number of other Centaurea species (DiTomaso 2000, p. 255; Davies and Svejcar 2008, pp. 623-629). Nonnative annual grasses (e.g., Bromus tectorum and Taeniatherum asperum) have caused extensive sagebrush habitat loss in the Intermountain West and Great Basin (Connelly et al. 2004, pp. 1-2 and 4-16). They impact sagebrush ecosystems by shortening fire intervals to as low as 3 to 5 years, perpetuating their own persistence and intensifying the role of fire (Whisenant 1990, p. 4). Connelly et al. (2004, p. 7-5) suggested that fire intervals are shortened to less than 10 years once invasive grasses become established. Although nonnative annual grasses occur throughout the sage-grouse's range, they are more problematic in western States (MZs III, IV, V, and VI) than Rocky Mountain States (MZs I and II) (Connelly et al. 2004, p. 5-9).

BLM (1996, p. 6) estimated that invasives (which may or may not have included Bromus tectorum) covered at least 3.2 million ha (8 million ac) of BLM lands as of 1994, and predicted 7.7 million ha (19 million ac) would be infested by 2000. However, a qualitative 1991 BLM survey covering 40 million ha (98.8 million ac) of all BLM-managed land in Washington, Oregon, Idaho, Nevada, and Utah (MZs III, IV, V, and VI) reported that introduced annual grasses were a dominant or significant presence on 7 million ha (17.2 million ac) of sagebrush ecosystems (Connelly et al. 2004, p. 5-10). An additional 25.1 million ha (62 million ac) had less than 10 percent B. tectorum in the understory, but were considered to be at risk of B. tectorum invasion (Zouhar 2003, p. 3, in reference to the same survey). More recently, BLM reported that as of 2000, noxious weeds and annual grasses occupied 11.9 million ha (29.4 million ac) of BLM lands in Washington, Oregon, Idaho, Nevada, and Utah (BLM 2007a, p. 3-28). However, when considering all States within the current range of sage-grouse, this number increases to 14.8 million ha (36.5 million ac; 31 percent of the species' range). Although estimates of the total area infested by B. tectorum vary widely, it is clear that B. tectorum is a significant presence in western rangelands. We received no new data quantifying the spread of noxious weeds and annual grasses in 2010.

Approximately 80 percent of land in the Great Basin Ecoregion (MZs III, IV, and V) is susceptible to displacement by Bromus tectorum (including over 58 percent of sagebrush that is moderately or highly susceptible) within 30 years (Connelly et al. 2004, p. 7-17, Suring et al. 2005, p. 138). Due to the disproportionate abundance of B. tectorum in the Great Basin, suggesting an increased susceptibility to B. tectorum invasion relative to other parts of the sage-grouse's range, Connelly et al. (2004, p. 7-8) cautioned that a formal analysis of the risk of B. tectorum invasion in other areas was needed before such inferences are made. Also, while nonnative annual grasses are usually associated with lower elevations and drier climates (Connelly et al. 2004, p. 5-5), the ecological range of B. tectorum continues to expand at low and high elevations (Ramakrishnan et al. 2006, pp. 61-62), both southward and eastward (Miller et al., 2011, p. 182). Local infestations of B. tectorum and other annual grasses occur in Montana, Wyoming, and Colorado (MZs I and II) (Miller et al., 2011, p. 160), and there is evidence that B. tectorum is impacting fire intervals in Wyoming. For example, 40,469 ha (100,000 ac) of sagebrush that burned in a wildfire southeast of Worland, Wyoming (MZ II), became infested with B. tectorum, accelerating the fire interval in this area (Wyoming Big Horn Basin Sage-grouse Local Working Group 2007, pp. 39-40). Annual brome canopy cover was 6.5 times higher at sites burned during the 1990's in this area of Wyoming, compared to more recent burns (Hess and Beck 2010, p. 50), suggesting that this annual grass persists years after initial burning of sagebrush.

Noxious weeds spread about 931 ha (2,300 ac) per day on BLM land and 1,862 ha (4,600 ac) per day on all public land in the West (BLM 1996, p. 1), or increase about 8 to 20 percent annually (Federal Interagency Committee for the Management of Noxious and Exotic Weeds 1997, p. v). Invasions are often associated with ground disturbances caused by wildfire, grazing, infrastructure, and other anthropogenic activity (Rice and Mack 1990, p. 84; Gelbard and Belnap 2003, p. 420; Zouhar et al. 2008, p. 23), but disturbance is not required for invasives to spread (Young and Allen 1997, p. 531; Roundy et al. 2007, p. 614). Invasions also may occur sequentially, where initial invaders (e.g., Bromus tectorum) are replaced by new exotics (Crawford et al. 2004, p 9; Miller et al., 2011, p. 160).

Based on data collected in the western half of the range, Bradley et al. (2009, pp. 1511-1521; Bradley 2009, pp. 196-208) predicted favorable conditions for Bromus tectorum across much of the sage-grouse's range under current and future (2100) climate conditions. A strong indicator for future B. tectorum locations is the proximity to current locations (Bradley and Mustard 2006, p. 1146) as well as summer, annual, and spring precipitation, and winter temperature (Bradley 2009, p. 196). Bradley et al. (2009, p. 1517) predicted that in the future some areas will become unfavorable for B. tectorum while others will become favorable. Specifically, Bradley et al. (2009, p. 1515) predicted that climatically suitable B. tectorum habitat will shift northwards, leading to expanded risk in Idaho, Montana, and Wyoming, but reduced risk in southern Nevada and Utah. Despite the potential for future retreat in Nevada and Utah, there will still be climatically suitable B. tectorum habitat in these States, well within the range of sage-grouse (see Figure 4b in Bradley et al. 2009, p. 1517). Bradley et al. (2009, p. 1511) noted that changes in climatic suitability may create restoration opportunities in areas that are currently dominated by invasives. We anticipate that B. tectorum will eventually disappear from areas that become climatically unsuitable for this species, but this transition is unlikely to occur suddenly. Also, Bradley et al. (2009, p. 1519) cautioned that areas that become unfavorable to B. tectorum may become favorable to other invasives, such as B. rubens (red brome) in the southern Great Basin, which is more tolerant of higher temperatures. Therefore, areas that become unsuitable for B. tectorum will not necessarily be returned to pre-invaded habitat conditions without significant effort.

The Landscape Fire and Resource Management Tool (LANDFIRE) provides vegetation and fire spatial data for analyses of fire risks and management. Annual grasses and other invasive plants are grossly underestimated in the (LANDFIRE) dataset because the dataset only includes monocultures of these species. Based on 1999-2002 imagery, at least 1.3 million ha (3.3 million ac) of other exotic plants occur within the current range of sage-grouse (LANDFIRE 2007). Aside from LANDFIRE, the only other information documenting the specific distribution of invasives within the sage-grouse's range is at a presence-absence scale at the county level. DiTomaso (2000, p. 257) estimated that western rangelands are infested with 2,900,000 ha (7,166,027 ac) of C. maculosa, 1,300,000 ha (3,212,357 ac) of C. diffusa, 8,000,000 ha (19,768,352 ac) of C. solstitialis, and 1,100,000 ha (2,718,148 ac) of Euphorbia esula, but this estimate did not describe the distribution of invasives across the landscape. These estimates, combined with estimates of acres infested by Bromus tectorum, and the fact that LANDFIRE detected more acres of other noxious weeds than annual grasses, illustrate the severity of the invasives problem.

Invasives that are not annual grasses impact the entire range of sage-grouse, although not all given species are distributed across the entire range. Like Bromus tectorum, the distribution of other invasives will likely shift with climate change. Bradley et al. (2009, p. 1518) predicts that the range C. maculosa will expand in some areas, mainly in parts of Oregon, Idaho, western Wyoming, and Colorado, and will contract in other areas (e.g., eastern Montana). They also predict that the range of C. solstitialis will expand eastward (Bradley et al. 2009, p. 1514) and that the invasion risk of Euphorbia esula will likely decrease in several States, including parts of Colorado, Oregon, and Idaho (Bradley et al. 2009, pp. 1516-1518).

Many efforts are ongoing to restore or rehabilitate sage-grouse habitat affected by invasive species. Common rehabilitation techniques include first reducing the density of invasives using herbicides, defoliation via grazing, pathogenic bacteria and other forms of bio-control, or prescribed fire (Tu et al. 2001; Larson et al. 2008, p. 250; Pyke, 2011, p. 543). Sites are then typically reseeded with grass and forb mixes, and sometimes planted with sagebrush plugs. Despite ongoing efforts to transform lands dominated by invasive annual grasses into quality sage-grouse habitat, restoration and rehabilitation techniques are considered to be mostly unproven and experimental (Pyke, 2011, pp. 543-544). Rehabilitation and restoration efforts also are hindered by cost and the ability to procure the equipment and seed needed for projects (Pyke, 2011, p. 544). Furthermore, restoration of sage-grouse habitat requires partnerships across multiple ownerships in order to restore and maintain a connective network of intact vegetation (Pyke, 2011, p. 548). Even if these issues can be resolved it will take time for sagebrush to establish and mature in areas currently dominated by annual grasses.

Treatment success also depends on factors which are not controllable, such as precipitation received at the treatment site (Pyke, 2011, p. 545). Areas with established annual grasses that receive less than 22.9 cm (9 in.) of annual precipitation are less likely to benefit from restoration (Connelly et al. 2004, p. 7-17, Carlson 2008b, pers. comm.). Consequently, BLM focuses most (98 percent) of their restoration efforts in areas receiving more than 22.9 cm (9 in.) of annual precipitation where there is greater chance of success. Of the BLM treatments in annual grasslands, only 10 percent of acres treated in areas receiving less than 22.9 cm (9 in.) of annual precipitation were considered to be effectively treated. In areas receiving between 22.9 cm (9 in.) and 30.5 cm (12 in.) of annual precipitation, 33.6 percent of the acres were treated effectively, and 3.3 percent of the acres were treated effectively in areas receiving greater than 30.5 cm (12 in.) of annual precipitation (Carlson 2008b, pers. comm.).

A variety of regulatory mechanisms and non-regulatory measures to control invasive plants exist. However, the extent to which these mechanisms effectively ameliorate the current rate of invasive expansion is unclear. If noxious weeds are spreading at a rate of 931 ha (2,300 ac) per day on BLM lands (BLM 1996, p. 1), this amounts to 339,815 ha (839,500 ac) per year, which includes both suitable and non-suitable habitat for sage-grouse. It is unclear whether this estimate is limited to noxious weeds or if includes other invasives (e.g., Bromus tectorum). Still, we can compare this estimate to the acres of all invasives (excluding conifers) treated by the BLM between October 2005 and September 2007; 259,897 ha (642,216 ac), which is approximately 86,632 ha (214,072 ac) treated annually. This rate of treatment is not keeping pace with the annual rate of spread (339,815 ha; 839,500 ac). Also, treatments are typically considered to be successful based on whether native vegetation was reestablished, maintained, or enhanced, and not based on a positive population response of sage-grouse to the treatment. Therefore, the effectiveness of treatments for sage-grouse is likely much less than reported for vegetation.

The National Invasive Species Council (2008, p. 8) acknowledges that there has been a significant increase in activity and awareness, but that much remains to be done to prevent and mitigate the problems caused by invasive species. As an example, the State of Montana has made much progress through partnerships in reducing noxious weeds in the State from 3.2 million ha (8 million ac) in 2000 to 3.1 million ha (7.6 million ac) in 2008 (Montana Weed Control Association 2008). However, the Montana Noxious Weed Summit Advisory Council Weed Management Task Force (2008, p. III) estimates that to slow weed spread and reduce current infestations by 5 percent annually, they require 2.6 times the current level of funding from a variety of private, local, State, and Federal sources (or $55.8 million versus $21.2 million). In addition to funding, other factors that potentially limit ability to control invasives include the amount of available native seed sources, the time it takes to restore sagebrush to an area once it is removed from a site, and the existence of treatments that are known to be effective in the long-term. Monitoring is limited in many cases and, where it occurs, monitoring typically does not document the population response of sage-grouse to these treatments.

Summary of Invasives

Invasives are a serious rangewide threat, and remain as one of the highest risk factors for sage-grouse based on the plants' ability to out-compete sagebrush, the inability to effectively control them once they become established, and the synergistic interaction between them and other risk factors on the landscape (e.g., wildfire, infrastructure construction). Because invasives are widespread, have the ability to spread rapidly, occur near areas susceptible to invasion, and are difficult to control, we anticipate that invasives will continue to replace and reduce the quality of sage-grouse habitat across the range in the foreseeable future. While some conservation efforts appear successful at smaller scales, prevention (e.g., early detection and fire prevention) appears to be the only known effective tool to preclude or minimize large-scale habitat loss from invasive species in the future.

<u>Pinyon-juniper Encroachment</u>

Pinyon-juniper woodlands are a native habitat type dominated by pinyon pine (Pinus edulis) and various juniper species (Juniperus spp.) that can encroach upon, infill, and eventually replace sagebrush habitat. These two woodland types are often referred to collectively as pinyon-juniper; however, some portions of the sage-grouse's range are only impacted by juniper encroachment. Commons et al. (1999, p. 238) found that the number of male Gunnison sage-grouse (C. minimus) on leks in southwest Colorado doubled after pinyon-juniper removal and mechanical treatment of mountain sagebrush and deciduous brush. Hence, we infer that some greater sage-grouse populations have been negatively affected by pinyon-juniper encroachment and that some populations will decline in the future due to projected increases in the pinyon-juniper type, especially in areas where pinyon-juniper encroachment is a large-scale threat (parts of MZs III, IV, and V). Doherty et al. (2008, p. 187) reported a strong avoidance of conifers by female greater sage-grouse in the winter, further supporting our previous inference. Also, Freese's (2009, pp. 84-85, 89-90)

2-year telemetry study in central Oregon found that sage-grouse used areas with less than 5 percent juniper cover more often in the breeding and summer seasons than similar habitat that had greater than 5 percent juniper cover. Therefore, pinyon-juniper encroachment into occupied sage-grouse habitat reduces, and likely eventually eliminates, sage-grouse occupancy in these areas.

Pinyon-juniper woodlands are often associated with sagebrush communities and currently occupy at least 18 million ha (44.6 million ac) of the Intermountain West within the sage-grouse's range (Crawford et al. 2004, p. 8; Miller et al. 2008, p. 1). Pinyon-juniper extent has increased 10-fold in the Intermountain West since European settlement causing the loss of many bunchgrass and sagebrush-bunchgrass communities (Miller and Tausch 2001, pp. 15-16). This expansion has been attributed to the reduced role of fire via suppression efforts, the introduction of livestock grazing, increases in global carbon dioxide concentrations, climate change, and natural recovery from past disturbance (Miller and Rose 1999, pp. 555-556; Miller and Tausch 2001, p. 15; Baker, 2011, p. 200; see also discussion under Fire above).

Connelly et al. (2004, pp. 7-8 to 7-14) estimated that approximately 60 percent of sagebrush in the Great Basin was at low risk of displacement by pinyon-juniper in 30 years, 6 percent at moderate risk, and 35 percent at high risk. Mountain big sagebrush appears to be most at risk of pinyon-juniper displacement (Connelly et al. 2004, pp. 7-13). When juniper increases in mountain big sagebrush communities, shrub cover declines and the season of available succulent forbs is shortened due to soil moisture depletion (Crawford et al. 2004, p. 8). As with Bromus tectorum, the Great Basin appears more susceptible to pinyon-juniper invasion than other areas of the sage-grouse's range; however, Connelly et al. (2004, pp. 7-8) cautioned that a formal analysis of the risks posed in other locations was needed before such inferences could be made.

Annual encroachment rates of pinyon-juniper reported in five studies ranged from 0.3 to 31 trees per hectare (0.7 to 77 trees per acre) (Sankey and Germino 2008, p. 413). The percent increase in juniper cover per year was reported at between 0.4 and 4.5 percent annually (Sankey and Germino 2008, p. 413).

Up to 90 percent of existing woodlands in the sagebrush-steppe and Great Basin sagebrush vegetation types were previously dominated by sagebrush vegetation prior to the late 1800s (Miller et al., 2011, p. 162). Based on past trends and the current distribution of pinyon-juniper relative to sagebrush habitat, we anticipate that expansion will continue at varying rates across the landscape and cause further loss of sagebrush habitat within the western part of the sage-grouse's range, especially in parts of MZs III, IV, and V. While pinyon-juniper expansion appears less problematic in the eastern portion of the range (MZs I, II and VII) and silver sagebrush areas (primarily MZ I), woodland encroachment is a threat mentioned in Wyoming, Montana, and Colorado State sage-grouse conservation plans, (Stiver et al. 2006, p. 2-23). Colorado's State plan specifically attributed some sage-grouse habitat loss in Colorado to pinyon-juniper expansion (Colorado Greater Sage-grouse Steering Committee 2008, pp. 179, 182). Furthermore, LANDFIRE (2007) data illustrates extensive coverage of pinyon-juniper woodlands in parts of northwest Colorado within the range of sage-grouse. These data also show limited pinyon-juniper coverage in Montana and Wyoming; however, LANDFIRE data could be a major underestimate of juniper because is difficult to classify pinyon-juniper woodlands with satellite imagery when it occurs at low densities (Hagen 2005, p. 142).

Many conservation actions have addressed this threat using a variety of techniques (e.g., mechanical, herbicide, cutting, burning) to remove conifers in sage-grouse habitat. In 2010 and early 2011 the NRCS entered into contracts with private landowners to remove nearly 20,234 ha (50,000 ac) of conifers across 7 states within the greater sage-grouse range (NRCS 2010, in litt.) The Wyoming Game and Fish Department (WGFD) and the Colorado Division of Wildlife (CDOW) also reported that they conducted approximately 283.3 ha (700 ac) and 1054 ha (2604 ac) of conifer removal in 2010, respectively (CDOW 2011, in litt.; WGFD 2011, in litt.). We are not aware of any study documenting a direct correlation between these treatments and increased greater sage-grouse productivity, particularly in the long-term; however, we infer some level of positive response based on Commons et al.'s (1999) Gunnison sage-grouse study and the documented avoidance, or reduced use, by sage-grouse of areas where pinyon-juniper has encroached upon sagebrush communities (Doherty et al. 2008, p. 187; Freese 2009, pp. 84-85, 89-90). The NRCS has initiated a research project to identify the effects of conifer removal in sagebrush habitats on sage-grouse, but the results will not be available for approximately 5 years (NRCS 2011, in litt.). Additionally the NRCS has contracted with The Nature Conservancy to create a spatial planning tool to identify where tree removal in sagebrush habitats will maximize biological benefits to the greater sage-grouse (NRCS 2011, in litt.). This tool is currently in development, and its efficacy will depend on accuracy of the final tool and results of the

research study.
While many acres have been treated since 2004, treatments are not likely keeping pace with the current rate of pinyon-juniper encroachment. For example, while Oregon treated approximately 8,094 ha (20,000 ac) of juniper to restore native sagebrush habitat between 2003 and early 2008 (about 1,619 ha or 4,000 ac per year; ODFW 2008, p. 3), LANDFIRE data show at least 106,882 ha (264,110 ac) of juniper occur within 4.8 km (3 mi) of Oregon leks. At this removal rate, it would take approximately 60 years to remove the threat of juniper encroachment within 3 miles of sage-grouse leks in Oregon, assuming expansion does not continue. Furthermore, not all treatments are effective. Of the 38,780 ha (95,826 ac) treated by BLM in Fiscal Year (FY) 2006 and FY 2007, only 21,598 ha (53,369 ac), or 55.7 percent were considered to be effective (Carlson 2008b, pers. comm.). Again, the measure of effectiveness typically refers to whether vegetation was treated successfully, and not whether sage-grouse use an area that has been treated.

Summary of Pinyon-juniper encroachment

Pinyon and juniper and some other native conifers are expanding into sagebrush habitats mainly due to decreased fire return intervals, livestock grazing, and increases in global carbon dioxide concentrations associated with climate change, among other factors. If unchecked, pinyon and juniper can replace sagebrush habitat, precluding its use by sage-grouse. A large portion of the Great Basin is at risk of pinyon-juniper encroachment within the next 30 years (Connelly et al. 2004, p. 7-8 to 7-14). Pinyon-juniper woodlands tend to expand into higher elevation sagebrush habitats, creating an elevational squeeze from both low and high elevations. Pinyon-juniper removal from sagebrush habitats, particularly when done in the early stages of encroachment when sagebrush and its associated forb understory is still intact, has the potential to provide an immediate benefit to sage-grouse. Several treatments to reduce this threat have been initiated across the species range. However, studies have not yet documented a correlation between pinyon-juniper treatments and increased greater sage-grouse productivity. Studies have been initiated to address this deficit, but results will not be known for several years. Therefore, the efficacy of these conservation efforts cannot be evaluated at this time.

<u>Energy Development</u>

Greater sage-grouse populations are negatively affected by energy development activities (primarily oil, gas, and coal-bed methane), especially those that degrade important sagebrush habitat, even when mitigative measures are implemented (Braun 1998, p. 144; Lyon 2000, pp. 25-28; Holloran 2005, pp. 56-57; Naugle et al. 2006, pp. 8-9; Walker et al. 2007a, p. 2651; Doherty et al. 2008, p. 192; Harju et al. 2010, p. 443)). Impacts can result from direct habitat loss, fragmentation of important habitats by roads, pipelines and powerlines (Kaiser 2006, p. 3; Holloran et al. 2007, p. 16), noise (Holloran 2005, p. 56), and direct human disturbance (Lyon and Anderson 2003, p. 489). The negative effects of energy development often add to the impacts from other human development and activities and result in sage-grouse population declines (Harju et al. 2010, p. 445; Naugle et al., in press, p. 1). For example, 12 years of coal-bed methane gas development in the Powder River Basin of Wyoming has coincided with 79 percent decline in the sage-grouse population (Emmerich 2009, pers. comm.). Population declines associated with energy development result from the abandonment of leks (Braun et al. 2002, p. 5; Walker et al. 2007a, p. 2649; Clark et al. 2008, pp. 14, 16), decreased attendance at the leks that persist (Holloran 2005, pp. 38-39, 50; Kaiser 2006, p. 23; Walker et al. 2007a, p. 2648; Harju et al. 2010, p. 443), lower nest initiation (Lyon 2000, p. 109; Lyon and Anderson 2003, p. 5), poor nest success and chick survival (Aldridge and Boyce 2007, p. 517), decreased yearling survival (Holloran et al., 2010, p. 6), and avoidance of energy infrastructure in important wintering habitat (Doherty et al. 2008, pp. 192-193).

Nonrenewable Energy Sources

Nonrenewable fossil fuel energy development (e.g., petroleum products, coal) has been occurring in sage-grouse habitats since the late 1800s (Connelly et al. 2004, p. 7-28). Interest in developing oil and gas resources in North America has been cyclic based on demand and market conditions (Braun et al. 2002, p. 2).

Between 2004 and 2008, the exploration and development of fossil fuels in sagebrush habitats increased rapidly as prices and demand were spurred by geopolitical uncertainties and legislative mandates (National Petroleum Council 2007, pp. 5-7), as detailed in our March 2010 status review (75 FR 13943). Legislative mandates include the Energy Policy and Conservation Act (EPCA) of 1975 (42 United States Code (U.S.C.) 6201 et seq.), the Energy Policy Act of 2000 (Public Law (P.L.) 106-469), and the 2005 Energy Policy Act (42 U.S.C. 15851). In addition, the 2005 Energy Policy Act ordered the identification of renewable energy sources (e.g., wind, geothermal) and provided incentives for development of renewable energy sources (42 U.S.C. 15851).

Forecasts to the year 2030 predict fossil fuels to continue to provide for the United States' energy needs while not necessarily in conventional forms or from present extraction techniques (EIA 2009b, pp. 2-4, 109). The decline in use of conventional fossil fuels for power generation in the future is expected to be supplemented with biomass, unconventional oil and gas, and renewable sources–all of which are existing or potentially available in current sage-grouse habitats (U.S. Department of Energy (DOE) 2006, p. 3; National Petroleum Council 2007, p. 6; BLM 2005a, p. 2-4; National Renewable Energy Laboratory (NREL) 2008a, entire; Idaho National Engineering and Environmental Laboratory 2003, entire; EIA 2009b, pp. 2-4). For example, oil shale and tar sands are unconventional fossil fuel liquids predicted for increased development in the sage-grouse range. Shale sources providing 2 million barrels per day in 2007 are expected to contribute 5.6-6.1 million barrels by 2030 (EIA 2009b, p. 30). Extraction of this resource involves removal of habitat and disturbance similar to oil and gas development (see discussion below) National reserves of oil shale lie primarily in the Uinta-Piceance area of Colorado and Utah (MZs II, III, and VII), and the Green River and Washakie areas of southwestern Wyoming (MZ II). These 1.4 million ha (3.5 million ac) of Federal lands contain an estimated 1.23 trillion barrels of oil – more than 50 times the United States' proven conventional oil reserves (BLM 2008a, p. 2).

Available EPCA inventories detail energy resources in 11 geological basins (DOI et al. 2008, entire) in the greater sage-grouse conservation assessment area (SGCA) identified in the 2006 Conservation Strategy (Stiver et al. 2006, p. 1-11). Extensive oil and gas reserves are identified in the Williston Basin of western North Dakota, northwestern South Dakota and eastern Montana; Montana Thrust Belt in west-central Montana; Powder River Basin of northeastern Wyoming and southeastern Montana; Wyoming Thrust Belt of extreme southwest Wyoming, northern Utah and southeastern Idaho; Southwest Wyoming Basin including portions of southwestern and central Wyoming, northeastern Utah and northwestern Colorado; Uinta-Piceance Basin of west-central Colorado and east-central Utah; Eastern Great Basin in eastern Nevada, western Utah and southern Idaho; and Paradox Basin in south-central and southeastern Utah (DOI et al. 2008, p. 3-11).

Oil and gas development has occurred in the past, with historical well locations concentrated in Wyoming, eastern Montana, western Colorado, and eastern Utah (IHS Incorporated 2006). Currently, oil, conventional gas, or coal-bed methane development occur across the eastern component of the SGCA. Four geological basins are most affected by a concentration of development – Powder River (MZ I), Williston (MZ I), Southwestern Wyoming (MZ II), and the Uinta-Piceance (MZs II, III, VII) coinciding with the highest proportion of high density areas of sage-grouse, the greatest number of leks, and the highest male sage-grouse attendance at leks compared with any other area in the eastern part of the range (Doherty et al. in press, p. 11). The Powder River Basin in northeast Wyoming and southeast Montana is home to an important regional population of the larger Wyoming Basin populations, which represents 25 percent of the sage-grouse in the species' range (Connelly et al. 2004, p. A4-37). The Powder River Basin serves as a link to peripheral populations in eastern Wyoming and western South Dakota and between the Wyoming Basin and central Montana. The Pinedale Anticline Project is in the Greater Green River area of the Southwest Wyoming Basin where the subpopulation in southwest Wyoming and northwest Colorado has been a stronghold for sage-grouse with some of the highest estimated densities of males per square kilometer anywhere in the remaining range of the species (Connelly et al. 2004, pp. 6-62, A5-23). The southwest Wyoming-northwest Colorado subpopulation has historically supported over 800 leks (Connelly et al. 2004, p. 6-62). The preservation of large contiguous blocks or interconnected patches of habitats that exist in southwest Wyoming area is considered a conservation priority for sage-grouse (Knick and Hanser in press, p. 31). Extensive development and operations are occurring in sage-grouse habitats where the number of producing wells has tripled in the past 30 years (Naugle et al., in press, p. 17). Over 8 percent of the distribution of sagebrush habitats is directly or indirectly affected by oil and gas development and associated pipelines (Knick et al. 2011, p. 237). Forty-four percent of the 16 million ha (39 million ac) Federal mineral estate in MZs I and II are leased and authorized for exploration and development (Naugle et al. in press, pp. 17-18). Wyoming contains the highest percentage of the Federal mineral estate with 10.6 million ha (26.2 million ac); 52 percent of it is authorized for development (Naugle et al., in press, pp. 17-18). Other Federal mineral estates in the eastern portion of the sage-grouse conservation assessment area that are authorized for development include at least 27 percent of Montana's 3.7 million ha (9.1 million ac), 50 percent of 915,000 ha (2.3 million ac) in Colorado, 25 percent of 405,000 ha (1.0 million ac) in Utah, and 14 percent of North and South Dakota's combined 365,000 ha (902,000 ac) (Naugle et al. in press, p. 38).

The Great Plains MZ (MZ I) contains all or portions of the 20.9 million ha (51.7 million ac) Powder River and Williston geological basins identified as significant oil and gas resources. The resource areas include 7.2 million ha (18.2 million ac) of sagebrush habitats. Oil and gas infrastructure and planned development occupies less than 1 percent of the land area in MZ I; however, the ecological effect is greater than 20 percent of the sagebrush habitat, based on applying a buffer zone to estimate the potential the distance of sage-grouse response to infrastructure (Lyon and Anderson 2003, p. 489; Knick et al., in press, p. 133). Energy development is concentrated in the Powder River geologic basin in northeast Wyoming and southeast Montana. Coal-bed natural gas extraction is the most recent development in the Powder River Basin which also is the largest actively-producing coal basin in the United States (Wyoming Mining Association 2008, p. 2).

In 2002, the BLM in Wyoming proposed development of 39,367 coal-bed methane wells and 3,200 conventional oil or gas wells in the Powder River Basin in addition to an existing 12,024 coal-bed methane wells drilled or permitted (BLM 2002, pp. 2-3). Wells would be developed over a 10-year period with production lasting until 2019 (BLM 2002, p. 3). The BLM estimated 82,073 ha (202,808 ac) of surface disturbance from all activities such as well pads, pipelines, roads, compressor stations and water handling facilities over a 3.2 million-ha (8 million ac) project area (BLM 2002, p. 2). Roads and water handling facilities were expected to be long-term disturbances encompassing approximately 38,501 ha (95,140 ac) (BLM 2002, p. 3). Reclamation of well sites was expected to be complete by 2022 (BLM 2002, p. 3). Between 1997 and 2007, approximately 35,000 producing wells were in place on Federal, State, and private holdings in the Powder River Basin area (Naugle et al., 2011, p. 492). In 2008, the BLM in Montana completed a supplement to the 2003 Environmental Impact Statement (EIS) and Record of Decision (ROD) to allow for 5,800-16,500 new coal bed methane wells in the Montana portion of the Powder River Basin over the pursuant 20 years (BLM 2008b, pp. 4.2, 4.4-4.5). In addition to the well footprint, each additional group of 2-10 wells has been shown to increase the number of new roads, power lines, and other infrastructure (Naugle et al. 2011, p. 492). Ranching, tillage agriculture, and energy development are the primary land uses in the Powder River Basin. The presence of human features and road densities are high in areas where all three activities coincide to the level that every 0.8 ha (0.5 mi) could be bounded by a road and bisected by a power line (Naugle et al. 2011, p. 493).

The Powder River Basin serves as a link to peripheral sage-grouse populations in eastern Wyoming and western South Dakota and between the Wyoming basin and central Montana. This connectivity is expected to be lost in the near future because of the intensity of development in the region. Sage-grouse populations have declined in the Powder River Basin by 79 percent since the development of coal-bed methane resources (Emmerich 2009, pers. comm.). In the Powder River Basin between 2001 and 2005, sage-grouse lek-count indices declined by 82 percent inside gas fields compared to 12 percent outside development (Walker et al. 2007a, p. 2648). By 2004-2005, fewer leks remained active (38 percent) inside gas fields compared to leks outside fields (84 percent) (Walker et al. 2007a, p. 2648). Sage-grouse are less likely to use suitable wintering habitat with abundant sagebrush when coal-bed methane development is present (Doherty et al. 2008, p. 192). At current maximum permitted well density (12 wells per 359 ha (888 ac)), planned full-field development will impact the remaining wintering habitat in the basin (Doherty et al. 2008, pp. 192, 194) and lead to extirpation.

Using GIS analysis, we calculated that 70 percent of the sage-grouse breeding habitat is potentially impacted by oil and gas development in the Powder River Basin (Service 2008b). This was derived from well point data supplied by the BLM, buffered by 3.2 km (2 mi) and intersecting these areas with known lek locations buffered to 6.4 km (4 mi; breeding habitat is defined as a 6.4-km (4-mi) radius around known lek points and includes the range of the average distances between nests and nearest lek (Autenrieth 1981, p. 18; Wakkinen et al. 1992, p. 2)). The 70 percent figure is conservative because the most comprehensive well point data set available did not reflect the rapid development that occurred in 2008.

Energy development in the Powder River Basin is predicted to continue to actively reduce sage-grouse populations and sagebrush habitats over the next 20 years based on the length of development and production projects described in existing project and management plans. The BLM concluded that sage-grouse habitats would not be restored to pre-disturbance conditions for an extended time (BLM 2003, p. 4-268). Sagebrush restoration after development is difficult to achieve, and successful restoration is not assured as described above (Habitat Description and Characteristics).

The 9.6 million ha (23.9 million ac) Williston Basin underlies the northeastern corner of the current sage-grouse range in Montana, North and South Dakota. Oil production has occurred in the Williston Basin for at least 80 years with oil production peaking in the 1980s (Advanced Resources International 2006, p. 3-3). Advances in technology including directional drilling and coal-bed methane technology have boosted development of oil and gas in the basin (Advanced Resources International 2006, p. 3.2; Zander 2008, p. 1). Large, developed fields are concentrated in the Bowdoin Dome area of north-central Montana and the 193-km (120 mi) long Cedar Creek Anticline area of southeastern Montana, southwestern North Dakota, and northwestern South Dakota. Extensive energy development in the Cedar Creek Anticline area could be isolating the very small North Dakota population from sage-grouse populations in central Montana and the northern Powder River Basin. Between 2008 and 2009 lek abundance decreased by 52 percent at 16 leks in the Cedar Creek Anticline area (Tack 2010, p. 21). Due to the time lag between onset of development and realization of the impacts on sage-grouse, Tack 2010 (p. 21) hypothesized that additional decreased rates of lek activity were likely.

One hundred and thirty-six wells were put into production in 2008-2009 in major oil and gas fields of the Williston Basin north of the Missouri River in the range of the Northern Montana sage-grouse population (Montana Department of Natural Resources 2009, entire) including the Bowdoin Dome area. The Bowdoin Dome area is populated by over 1,500 gas wells with associated infrastructure, and an additional 1,200 new or replacement wells were approved in the remaining occupied active sage-grouse habitat (BLM 2008c, pp. 1, 3-127 to 3-129). Active drilling operations are expected to occur over 10-15 years, and gas production is expected to extend the project life 30-50 additional years (BLM 2008c, p. 1). The BLM's project description does not take into consideration the time period necessary to restore native sagebrush communities to suitability for sage-grouse. Energy extraction, ranching and tillage agriculture coincide in this area of the State described by Leu and Hanser (2011, p. 267) as experiencing high-intensity human activity that is consistent with lek loss and population decline (Wisdom et al., 2011, p. 467). Energy development in Montana has contributed to post-settlement sage-grouse range contraction and possibly the geographic separation of the existing subpopulations in northern Montana and Canada. Foreseeable development is expected to further reduce the remaining sage-grouse habitat within developed oil and gas fields, and contribute to future range and population reductions (Copeland et al. 2009, p. 5).

Southwest and central Wyoming and northwest Colorado in MZ II has been considered a stronghold for sage-grouse with some of the highest estimated densities of males anywhere in the remaining range of the species (Connelly et al. 2004, pp. 6-62, A5-23). Wisdom et al. (2011, p. 469) identified this high density sagebrush area as one of the highest priorities for conservation consideration as it comprises one of two remaining areas of contiguous range essential for the long-term persistence of the species. The Southwestern Wyoming geological basin also is experiencing significant growth in energy development which, based on the conclusions of recent investigations on the effects of oil and gas development, expected over time to reduce sage-grouse habitat, increase fragmentation, and decrease and isolate sage-grouse populations leading to extirpations.

Oil, gas, and coal-bed methane development is occurring across MZ II, and development is concentrated in some areas. Intensive development and production is occurring in the Greater Green River area in southwest Wyoming and northern Colorado and northeast Utah. The Pinedale Anticline Project Area in southwest Wyoming includes up to 900 drill pads, including dry holes, over a 10- to 15-year development period (BLM 2008d, p. 4-4). By the end of 2005, approximately 457 wells on 322 well pads were under production (BLM 2008d, p. 6). The project has been subsequently amended to accommodate an accelerated rate of development exceeding that in the original project description (BLM 2008d, p. 4), adding 250 new well pads in addition to pipelines and other facilities (BLM 2008d, p. 36). Total initial direct disturbance acres for the entire Pinedale project are approximately 10,400 ha (25,800 ac) with over 7,200 ha (18,000 ac) in sagebrush land cover type (BLM 2008d, p. 4-52).

The Jonah Gas Infill Project in the Pinedale Anticline area of the Southwest Wyoming Basin expands on the Jonah Project started in 2000. The existing project will be extended by an additional 3,100 wells and up to 6,556 ha (16,200 ac) of new surface disturbance (BLM 2006, p. 2-4). Well pad density will be at least 64 per 259 ha (640 ac), and up to 761 km (473 mi) of pipeline and roads, 56 ha (140 ac) of additional disturbance for ancillary facilities (p. 2-5) also would occur. The project life of 76 years includes 13 years of development and 63 years of production (BLM 2006, p. 2-15). This project is located in high density sage-grouse habitat, but it is not clear from the project description if suitable sage-grouse habitat is the reclamation goal. Therefore, sagebrush habitats, and the associated sage-grouse are likely to be lost.

Knick et al. (2011, p. 237) reviewed BLM documents for the Greater Green River Basin area, which includes the Pinedale and Jonah projects, and reported that 6,185 wells have been drilled, and there are agency plans for more than 9,300 wells and associated infrastructure. Existing and planned energy development influences over 20 percent of the sagebrush area in the Wyoming Basin (MZ II) (Knick et al., 2011, p. 240). Drilling, gas production, and traffic on main haul roads have all been shown to affect lek attendance and lek persistence when it coincides with breeding habitat within 3.2 km (2 mi) (Holloran 2005, p. 40; Walker et al. 2007a, p. 2651). Using 2006 well point data and, therefore, a conservative estimate as oil exploration and development experienced significant growth between 2006 and 2008, we calculated that 21 to 35 percent of active breeding habitat for subpopulations in the Southwest Wyoming geological basin may be negatively impacted by the proximity of energy development (Service 2008b).

In the Greater Green River Basin area, yearling male sage-grouse reared near gas field infrastructure had lower survival rates and were less likely to establish breeding territories than males with less exposure to energy development; yearling female sage-grouse avoided nesting within 950 m (0.6 mi) of natural gas infrastructure (Holloran et al. 2010, p. 70). The fidelity of sage-grouse to natal sites may result in birds staying in areas with development but not breeding (Lyon and Anderson 2003, p. 49; Walker et al. 2007a, p. 2651; Holloran et al. 2010, p. 70). The effect of energy development on sage-grouse population numbers may then take 4 to 5 years to appear (Walker et al. 2007a, p. 2651). Copeland et al. (2009, p. 5) depicted an extensive development scenario for southwest Wyoming, northern Colorado, and northeastern Utah based on known reserves and existing project plans that indicates an intersection between future oil and gas development and high density sage-grouse core areas that could result in a 6.3 to 24.1 percent decrease in sage-grouse numbers over the next 20 years in MZ II (Copeland 2010, pers. comm.).

The Greater Green River area of southwest Wyoming and the Uintah-Piceance basin (discussed below) also are important reserves of oil shale and tar sands (in addition to oil and gas) that are expected to supply more of the nation's resource needs in the future (EIA 2009b, p. 30). The Uintah-Piceance geologic basin includes the Colorado Plateau (MZ VII) and overlaps into the southern edge of the Wyoming Basin (MZ II). Sage-grouse in this part of the range are reduced to four small, isolated populations, a likely consequence of urban and agricultural development (Knick et al., 2011, p. 363; Leu and Hanser, 2011, p. 270). All four populations are threatened by environmental, demographic, and genetic stochasticity due to their small population sizes as well as housing and energy development, predation, disease, and conifer invasion (Garton et al., in press, p. 7; Petch 2009, pers. comm.; Maxfield 2009, pers. comm.).

Based on applying a 3 km (1.9 mi) buffer to construction areas, Knick et al. (2011, p. 240) estimate existing energy development affects over 30 percent of sagebrush habitats in this area In the past 4 years, the number of oil and gas wells increased in sage-grouse habitats of northwestern Colorado and northeastern Utah by 325 and 870 wells, respectively (Service 2008c). No positive influence of non-renewable energy developments on either sage-grouse populations or their habitats were found in a literature review of 14 studies (Naugle et al., 2011, p. 56). Over 1,370 wells were completed in Uintah (location of the two Utah populations) and Duchesne Counties of northeast Utah between July 2008 and August 2009 (Utah Oil and Gas Program 2009, entire), and approximately 7,700 wells are active in the counties (Utah DNRC 2009, entire). We expect that the development of energy resources will continue based on available reserves and recent development history (Copeland et al. 2009, p. 5), and development will further stress the persistence of these small populations at the southern edge of the sage-grouse range.

The effects of oil and gas development are likely to continue for decades even with the current protective or mitigative measures in place. Based on a review of project EIS's, Connelly et al. (2004, p. 7-41) concluded that the economic life of a coal-bed methane well averages 12-18 years and 20-100 years for deep oil and gas wells. A recent review of energy projects in development, primarily gas and coal-bed methane, supports these time frames (BLM 2008b, p. 4-2; 2008c, p. 2; 2009b, p. 2). In addition, many energy projects are tiered to the 20-year land use plans developed by individual BLM field offices or districts to guide development and other activities.

Although the restrictive stipulations that BLM applies to permits and leases are variable, a 0.4-km (0.25-mi) radius around sage-grouse leks is generally restricted to NSO during the breeding season, and noise and development activities are often limited during the breeding season within a 0.8 to 3.2-km (0.5 to 2-mi) radius of sage-grouse leks. The BLM's NSO buffer stipulation is ineffective in protecting sage-grouse (Walker et al. 2007a, p. 2651) and it is not applied or applicable to all development sites. We estimated the sage-grouse breeding habitat impacted within 0.4 km (0.25 mi) of a producing well or drilling site with a an approved BLM permit using 2006 well-site locations (the most comprehensive data available to us). Figures derived from the 2006 data are conservative because the rapid pace of development in 2007 and 2008 is not reflected. Within 16.2 million ha (38 million ac) of sage-grouse breeding habitat in MZs I and II (where 65 percent of all sage-grouse reside), approximately 1.7 million ha (4.2 million ac) or 10 percent are within 0.4 km (0.25 mi) of a producing well, drilling operation or site (Service 2008d). Walker et al. (2007a, p. 2651) reported negative impacts on lek attendance of coal-bed methane development within 0.8 km (0.5 mi) and 3.2 km (2 mi) of a lek, and Holloran (2005, pp. 57-60) observed that the influence of producing well sites and mail haul roads on lek attendance extended to at least 3 km (2 mi). Expanding our analysis area from 0.4 km (0.25 mi) to include breeding habitat within 3 km (2 mi) of producing well or drilling sites with an approved BLM permit, we determined that 40 percent of the sage-grouse breeding habitat in MZs I and II is potentially affected by oil or gas development (Service 2008b). In some cases, localized areas are experiencing higher levels of effects. Seventy percent of the sage-grouse breeding habitat is within 3 km (2 mi) of development in the Powder River Basin of northeastern Wyoming and southeastern Montana (Service 2008b), where Walker et al. (2007, p. 2651) concluded that full-field development would reduce the probability of lek persistence from 87 to 5 percent. Our analyses show that subpopulations of sage-grouse in MZ II have up to 35 percent of breeding habitat within 3.2 km (2 mi) of development, and where data are available for populations in the Uintah-Piceance Basin of Colorado and Utah, 100 percent of the breeding habitat is affected by oil and gas development (Service 2008b). Additionally these calculations do not take into account the added effects of loss of habitat or habitat effectiveness resulting from the increasing level of renewable energy development or other anthropogenic factors occurring in concert with oil and gas development such as tillage, urban expansion, or predation, fire and invasives (see discussions under those headings).

Energy development impacts sage-grouse and sagebrush habitats through direct habitat loss from well pad, access construction, seismic surveys, roads, powerlines and pipeline corridors; indirectly from noise, gaseous emissions, changes in water availability and quality, and human presence; and the interaction and intensity of effects could cumulatively or individually lead to habitat fragmentation (Suter 1978, pp. 6-13; Aldridge 1998, p. 12; Braun 1998, pp. 144-148; Aldridge and Brigham 2003, p. 31; Knick et al. 2003, pp. 612, 619; Lyon and Anderson 2003, pp. 489-490; Connelly et al. 2004, pp. 7-40 to 7-41; Holloran 2005, pp. 56-57; Holloran et al. 2007, pp. 18-19; Aldridge and Boyce 2007, pp. 521-522; Walker et al. 2007a, pp. 2652-2653; Zou et al. 2006, pp. 1039-1040; Doherty et al. 2008, p. 193; Leu and Hanser, 2011, p. 267).

Details of the necessary steps for the development of oil and gas resources are provided in our March 2010 status review (75 FR 13946). Well pads vary in size from 0.10 ha (0.25 ac) for coal-bed natural gas wells in areas of level topography to greater than 7 ha (17.3 ac) for deep gas wells and multiwell pads (Connelly et al. 2004, p. 7-39; BLM 2007c, p. 2-123). Pads for compressor stations require 5-7 ha (12.4-17.3 ac) (Connelly et al. 2004, p. 7-39). Well densities and spacing are typically designed to maximize recovery of the resource (Connelly et al. 2004 pp. 7-39 to 7-40). Each geologic basin has a standard spacing, but exemptions are granted. Density of wells for current major developments in the sage-grouse range vary from 1 well per 2 ha (5ac) to 1 well per 64 ha (158 ac) (Knick et al., 2011, p. 242). Greater sage-grouse respond to the density and distribution of infrastructure on the landscape. Holloran (2005, pp. 38-39, 50) reported that male sage-grouse attendance at leks decreased by over 23 percent in gas fields where well density was 5 or more within 3 km (1.9 mi). Sage-grouse are less likely to occupy areas with wells at a 32 ha (80 ac) spacing than a 400 ha (988 ac) spacing (Doherty et al. 2008, p. 193). Sage-grouse also appear to avoid wintering habitats near natural gas development associated with high levels of human activities (Wyoming Wildlife Consultants 2009 in litt.) Direct habitat loss from the human footprint contributes to decreased population numbers and distribution of the greater sage-grouse (Knick et al. 2003, p. 1; Connelly et al. 2004, p. 7-40; Aldridge et al. 2008, p. 983; Copeland et al. 2009, p. 6; Knick et al., 2011, p. 251; Leu and Hanser, 2011, p. 255). The ecological footprint is the extended effect of the infrastructure or activity beyond its physical footprint and determined by a physical or behavioral response of the sage-grouse. The physical footprint of oil and gas infrastructure including pipelines is estimated to be 5 million ha (1.2 million ac) and less than 1 percent of the sage-grouse assessment area (Knick et al., 2011, p. 237). However, the estimated ecological footprint is over 13.8 million ha (34.2 million ac) or 6.7 percent of the SGCA (Knick et al., 2011, p. 237) based on applying a buffer zone to estimate potential avoidance, increased mortality risk, and lowered fecundity in the vicinity of development (Lyon and Anderson 2003, p. 459; Walker et al. 2007a, p. 2651; Holloran et al. 2010, p. 6). Based on their method, Knick et al. (2011, p. 237) estimated over 8 percent of sagebrush habitats within the SGCA are affected by energy development Copeland et al. (2009, p. 6) predict a scenario with a minimum of 2.3 million additional ha (5.7 million ac) directly impacted by oil and gas development by the year 2030. The corresponding ecological footprint is likely much larger. The projected increase in oil and gas energy development within the sage-grouse range could reduce the population by 7 to 19 percent from today's numbers (Copeland et al. 2009, p. 6). This projection does not reflect the effects of the increased development of renewable energy sources.

Roads associated with oil and gas development were suggested to be the primary impact to greater sage-grouse due to their persistence and continued use even after drilling and production ceased (Lyon and Anderson 2003, p. 489) (see also discussion under roads above). Roads associated with oil and gas field development may be contributing to higher abundances of synanthropic predators (predators who are associated with humans, such as the red fox), which in turn may be affecting sage-grouse persistence and productivity. Holloran (2005, p. 58) attributed increased sage-grouse nest depredation to high corvid abundances, which resulted from anthropogenic food and perching subsidies in areas of natural gas development in western Wyoming. Bui (2009, p. 31) also found that ravens used road networks associated with oil fields in the same Wyoming location for foraging activities, but could not prove a causal link between raven occurrence and sage-grouse reproductive failure (Bui et al. 2010, p. 75). Holmes (unpubl. data) also found that common raven abundance increased in association with oil and gas development in southwestern Wyoming. The influence of synanthropic predators in the Wyoming Basin is important as this area has one of the few remaining clusters of sagebrush landscapes and the most highly connected network of sage-grouse leks (Knick and Hanser 2011, p.391). The presence of high numbers of predators within a sage-grouse nesting area may negatively affect sage-grouse productivity without causing direct mortality. Coates (2007, p. 85-86) suggested that ravens may reduce the time spent off the nest by female sage-grouse, thereby potentially compromising their ability to secure sufficient nutrition to complete the incubation period.

Habitat fragmentation resulting from oil and gas development infrastructure, including access roads, may have effects on sage-grouse greater than the associated direct habitat losses. The Powder River Basin infrastructure footprint is relatively small (typically 6-8 ha per 2.6 km2 (15-20 ac per section)). Considering the mostly contiguous nature of the project area, the density of facilities could affect sage-grouse habitats on over 2.4 million ha (5.9 million ac). Energy development and associated infrastructure works cumulatively with other human activity or development to decrease available habitat and increase fragmentation. Walker et al. (2007a, p. 2652) determined that leks had the lowest probability of persisting (40-50 percent) in a landscape with less than 30 percent sagebrush within 6.4 km (4 mi) of the lek. These probabilities were even less in landscapes where energy development also was a factor.

Noise can drive away wildlife, cause physiological stress and interfere with auditory cues and intraspecific communication. Aldridge and Brigham (2003, p. 32) reported that, in the absence of stipulations to minimize the effects of noise, mechanical activities at well sites may disrupt sage-grouse breeding and nesting activities. Hens bred on leks within 3 km (1.9 mi) of oil and gas development in the upper Green River Basin of Wyoming selected nest sites with higher total shrub canopy cover and average live sagebrush height than hens nesting away from disturbance (Lyon 2000, p. 109). The author hypothesized that exposure to road noise associated with oil and gas drilling may have been one cause for the difference in habitat selection.

However, noise could not be separated from the potential effects of increased predation resulting from the presence of a new road. In the Pinedale Anticline area of southwest Wyoming, lek attendance declined most noticeably downwind from a drilling rig indicating that noise likely affected male presence (Holloran 2005, p. 49). Above-ground noise is typically not regulated to mitigate effects to sage-grouse or other wildlife (Connelly et al. 2004, p. 7-40), although recent developments have incorporated restrictions to keep noise associated with energy development to 39 decibels or less. The effectiveness of this restriction is unknown. Ground shock from seismic activities may affect sage-grouse if it occurs during the lekking or nesting seasons (Moore and Mills 1977, p. 137). We are unaware of any research on the impact of ground shock to sage-grouse.

Water quality and quantity may be affected by oil and gas development. In many large field developments, the contamination threat is minimized by storing water produced by the gas dehydration process in tanks. Water also may be depleted from natural sources for drilling or dust suppression purposes. Concentrating wildlife and domestic livestock may increase habitat degradation at remaining water sources. Negative effects of changes in water quality, availability and distribution are a reduction in habitat quality (e.g., trampling of vegetation, changes in water filtration rates), and habitat degradation (e.g., poor vegetation growth), which could result in brood habitat loss. However, we have no data to suggest that this, by itself, is a limiting factor to sage-grouse.

Water produced by coal-bed methane drilling may benefit sage-grouse through expansion of existing riparian areas and creation of new areas (BLM 2003, p. 4-223). These habitats could provide additional brood rearing and summering habitats for sage-grouse. However, the increased surface-water on the landscape may negatively impact sage-grouse populations by providing an environment for disease vectors (Walker and Naugle 2011, p. 132). Based on the 2002 discovery of WNv in the Powder River Basin, and the resulting mortalities of sage-grouse (Naugle et al. 2004, p. 705), there is concern that produced water could have a negative impact if it creates suitable breeding reservoirs for the mosquito vector of this disease (see also discussion in Factor C, Disease and Predation). Produced water also could result in direct habitat loss through prolonged flooding of sagebrush areas, or if the discharged water is of poor quality because of high salt or other mineral content, either of which could result in the loss of sagebrush or grasses and forbs necessary for foraging broods (BLM 2003, p. 4-223).

Air quality could be affected where combustion engine emissions, fugitive dust from road use and wind erosion, natural gas-flaring, fugitive emissions from production site equipment, and other activities (BLM 2008d, p. 4-74) occur in sage-grouse habitats. Presumably, as with surface mining, these emissions are quickly dispersed in the windy, open conditions of sagebrush habitats (Moore and Mills 1977, p. 109), minimizing the potential effects on sage-grouse. However, high-density development could produce airborne pollutants that reach or exceed quality standards in localized areas for short periods of time (BLM 2008d, pp. 4-82 to 4-88). Walker (2008, entire) characterized emissions from well flaring in the Pinedale Anticline area of Sublette County, Wyoming. The investigator suggested a comprehensive study be conducted by regulatory agencies of the potential health effects of alkali elements in combusted well-plume material (Walker 2008, entire). No information is available regarding the effects to sage-grouse of gaseous emissions produced by oil and gas development. Ozone levels in the Pinedale Anticline and surrounding areas exceeded the Environmental Protection Agency limits on 13 days in 2011 (Forbes 2011).). The elevated levels have been attributed to the energy activity, and confounding weather conditions. While elevated ozone levels can result in respiratory problems for humans, the impact of these elevated levels on sage-grouse are unknown.

Negative effects of direct habitat disturbance can be offset by successful reclamation. Reclamation of areas disturbed by oil and gas development can be concurrent with field development or conducted after the shut-in or abandonment of the well or field. Sage-grouse may repopulate the area as disturbed areas are reclaimed. However, there is no evidence that populations will attain their previous size, and reestablishment may take 20 to 30 years (Braun 1998, p. 144). For most developments, return to pre-disturbance population levels is not expected due to a net loss and fragmentation of habitat (Braun et al. 2002, p. 150). After 20 years, sage-grouse have not recovered to pre-development numbers in Alberta, even though well pads in these areas have been reclaimed (Braun et al. 2002, pp. 4-5). In some reclaimed areas, sage-grouse have not returned (Aldridge and Brigham 2003, p. 31).

Since publication of our March 2010 status review (75 FR 13910) several oil and gas energy developments have been proposed or are in production within the range of the greater sage-grouse. Two developments in

South Dakota occurred in areas of abandoned leks, but the cause of abandonment was not identified (SDFGP 2011, in litt.). Drilling activities in the Piceance area of Colorado (as discussed above) increased in 2010, although economic conditions tempered the rate of development (CDOW 2011, in litt.). CDOW anticipates that energy production will increase as economic conditions improve (CDOW 2011, in litt.). Increased drilling activities have also occurred in other sage-grouse habitats in Colorado, although they have not been extensive. However, leasing activities have accelerated in northwestern Colorado for exploration purposes. If exploratory wells are productive, it is anticipated that extended development will occur, with well densities reaching 1 well per 64.7 ha (160 ac) (CDOW 2011, in litt.). Similar well densities have been demonstrated to have negative impacts on sage-grouse persistence (see discussion above). The Ruby Natural Gas Pipeline, which crosses sage-grouse habitats in Wyoming, Utah, Nevada and Oregon, is likely to result in short-term impacts to nesting habitats, increased human disturbance due to construction, maintenance and habitat restoration (NDOW 2011, in litt.), and potentially direct loss of habitats if restoration is ineffective.
The Bureau of Land Management reported that 4,153,783.7 ha (10,264,223 ac) within greater sage-grouse habitats across 10 states are currently leased for oil and gas development. Of that number 607,053.55 ha (1,500,062 ac) are in production (BLM 2011, in litt.). It is unclear how these values overlap with existing developments or those that are only proposed. Several of these leases have been deferred in some states pending completion of Resource Management Plans or NEPA planning documents, which will ultimately define sage-grouse protective measures (see discussion under Regulatory Mechanisms below). For example, 251,000 ha (620,000 ac)) have been deferred in Montana, and Utah BLM deferred all or portions of 111 oil and gas parcels (encompassing approximately 75,000 ha (185,500 ac)) in crucial sage-grouse habitat until adequate planning or NEPA analysis can be completed.

In summary, non-renewable energy development is a significant risk to the greater sage-grouse in the eastern portion of its range (Montana, Wyoming, Colorado, and northeastern Utah – MZs I, II, VII and the northeastern part of MZ III), by eliminating habitat, leks, and whole populations and fragmenting some of the last remaining large expanses of habitat necessary for the species' persistence. Continued exploration and development of traditional and nonconventional fossil fuel sources in the eastern portion of the greater sage-grouse range is predicted to continue to increase over the next 20 years (EIA 2009b, p. 109) with concurrent sage-grouse population declines (Copeland et al. 2009, p. 4).

Mining
Mining began in the range of the sage-grouse before 1900 (State of Wyoming, 1898; U.S. Census 1913, p. 187) and continues today. Currently, surface and subsurface mining activities for numerous resources are conducted in all 11 States across the sage-grouse range. Nevada (MZs III, IV, and V) is ranked second in the United States in terms of value of overall nonfuel mineral production in 2006 (USGS 2007, p. 10). Wyoming (MZs I and II) is the largest coal producer in the United States, and the top ten producing mines in the country are located in Wyoming's Powder River Basin (MZ I) (Wyoming Mining Association 2008, p. 2). A preliminary estimate of at least 9.9 km2 (3.8 mi2) of occupied sage-grouse habitat will be directly impacted by new or expanded mining operations, currently in the planning phase, for coal in Montana (MZ I) and Utah (MZ III), for phosphate in Idaho (MZ IV), and uranium in Nevada (MZ IV) and Wyoming (MZs I and II) (Service 2008b). The proposed expansion of a coal mine in Colorado will result in direct habitat loss of approximately 809.4 ha (2,000 ac) of important brood-rearing and late summer-fall habitat. Two leks will also be removed and an third will be within one-mile of disturbance (CDOW 2011, in litt.). A proposed surface coal conveyer belt for a different mine will bisect approximately 6.4 km (4 mi) of habitat of sage-grouse habitats in north-central Colorado (CDOW 2011, in litt.). While the area of impacts are relatively small, these mines are occurring in high quality habitats.
Uranium mining and milling has occurred in Wyoming, Utah, and Colorado, and Nevada within the greater sage-grouse conservation area; however, recent production has been very limited with only one operation in production in Wyoming (EIA 2009c, entire). Tax credits indicated in the 2005 Energy Policy Act and concerns for green-house gas emissions associated with fossil-fuel electricity generation are expected to increase nuclear power generation (EIA 2009b, p. 73) and stimulate the demand for uranium. Areas in central Wyoming and Wyoming's Powder River Basin are considered major reserves of uranium coinciding with areas of high sage-grouse population densities (Finch 1996, pp. 19-20; Wyoming State Governor's

Sage-grouse Implementation Team 2008, entire).

Bentonite mining has been conducted on over 85 km2 (33 mi2) in the Bighorn Basin of north-central Wyoming (EDAW, Inc. and BLM 2008, p. 1). Bentonite is a primary component of oil and gas drilling muds. The loss of sagebrush associated with bentonite mining has been intensive on a localized level and has contributed to altering 12 percent of the sagebrush habitats in the 2,173 km2 (839 mi2) Bighorn Basin (EDAW Inc., and BLM 2008, p. 2). Restoration efforts at mine sites have been mostly unsuccessful (EDAW, Inc. and BLM 2008, p. 1). The BLM foresees up to 89 additional km2 (34 mi2) to be disturbed by bentonite mining in the area through 2024, in addition to possible oil and gas and energy transmission disturbances (EDAW, Inc. and BLM 2008, p. 2; BLM 2009c, p. 5). Two bentonite mines were initiated in South Dakota, totaling 203.5 ha (503 ac) within a 3-mile buffer around leks (SDGFP 2011, in litt.).

Between 2006 and 2007, surface coal production decreased 9 percent in Colorado while increasing by 1.6 and 4.4 percent in Wyoming (MZ I) and Montana (MZ I), respectively (EIA 2008a, entire). The number of Wyoming coal mines increased from 19 in 2005 to 23 in 2008 (Wyoming Mining Association 2005, p. 5). All of Wyoming's 23 coal mines are in sagebrush and in the greater sage-grouse assessment area. Sixteen of these mines are located in the Powder River Basin (MZ I) where oil and gas development is extensive (Wyoming Mining Association 2008, p. 2). Coal mining in Montana is focused in the Powder River Basin just north of the Wyoming border, in sagebrush habitat. In Wyoming and Montana, an estimated 558 km2 (215 mi2) of sagebrush habitats have been disturbed by coal mines and associated facilities; disturbance increased approximately 170 km2 (66 mi2) between 2005 and 2007 (Service 2005, p. 75; Service 2008c; Wyoming Mining Association 2008, p. 7). Wyoming estimates that 275 km2 ha (106 mi2) of mine-disturbed land has been reclaimed (Wyoming Mining Association 2008, p. 7), but we have no knowledge of the effectiveness of these reclamation projects in providing functional sage-grouse habitat.

While western coal production has grown steadily since 1970, it is predicted that growth will increase through 2030, but at a much slower rate than in the past (EIA 2009b, p. 83). Coal production is projected to increase with the development of technology to reduce sulfur emissions and most of the future output of coal is expected from low-sulfur coal mines in Wyoming, Montana, and North Dakota (EIA 2009b, p. 83). We do not have information to quantify the footprint of future coal production; however additional losses and deterioration of sage-grouse habitats are expected where mining activity occurs. The use of coal may be reduced if limitations on green-house gas emissions are enacted in the future. A transition would require development of lower-emission sources of energy, such as wind, solar, or nuclear, that may have their own impacts on sage-grouse environments.

Surface and subsurface mining for mineral resources (coal, uranium, copper, phosphate, aggregate and others) results in direct loss of habitat if occurring in sagebrush habitats. The direct impact from surface mining is usually greater than it is from subsurface activity. Habitat loss from both types of mining can be exacerbated by the storage of overburden (soil removed to reach subsurface resource) in otherwise undisturbed habitat. If the construction of mining infrastructure is necessary, additional direct loss of habitat could result from structures, staging areas, roads, railroad tracks and powerlines. Sage-grouse and nests could be directly affected by trampling or vehicle collision. Sage-grouse also will likely be impacted indirectly from an increase in human presence, land use practices, ground shock, noise, dust, reduced air quality, degradation of water quality and quantity, and changes in vegetation and topography (Moore and Mills 1977, entire; Brown and Clayton 2004, p. 2).

An increase in human presence increases collision risk with vehicles and potentially exposes sage-grouse and other wildlife to pathogens introduced from septic systems and waste disposal (Moore and Mills 1977, pp. 114-116, 135). Water contamination also could occur from leaching of waste rock and overburden and nutrients from blasting chemicals and fertilizer (Moore and Mills 1977, pp. 115, 133). Altering of water regimes could lead to decreased surface water and eventual habitat degradation from wildlife or livestock concentrating at remaining sources. Sage-grouse do not require water other than what they obtain from plant resources (Schroeder et al. 1999, p. 6); therefore, local water quality deterioration or dewatering is not expected to have population-level impacts. Degradation of riparian areas could result in a loss of brood habitat.

Heavy equipment operations and use of unpaved roads produces dust that can interfere with plant photosynthesis and insect populations. Most large surface mines are required to control dust. Gaseous emissions generated from heavy equipment operation are quickly dispersed in open, windy areas typical of sagebrush (Moore and Mills 1977, p.109). Blasting, to remove overburden or the target mineral, produces noise and ground shock. The full effect of ground shock on wildlife is unknown. Repeated use of explosives during lekking activity could potentially result in lek or nest abandonment (Moore and Mills 1977, p. 137). Noise from mining activity could mask vocalizations resulting in reduced female attendance and yearling recruitment as seen in sharp-tailed grouse (Pedioecetes phasianellus) (Amstrup and Phillips 1977, pp. 23, 25-27). In this study, the authors found that the mining noise in the study area was continuous across days and seasons and did not diminish as it traveled from its source. The mechanism of how noise affects sage-grouse is not known but it is known that sage-grouse depend on acoustical signals to attract females to leks (Gibson and Bradbury 1985, pp. 81-82; Gratson 1993, pp. 693-694). Noise associated with oil and gas development may have played a factor in habitat selection and a decrease in lek attendance by sage-grouse (Holloran 2005, pp. 49, 56).

A few scientific studies specifically examine the effects of coal mining on greater sage-grouse. In a study in North Park, Colorado, overall sage-grouse population numbers were not reduced, but there was a reduction in the number of males attending leks within 2 km (0.8 mi) of three coal mines, and existing leks failed to recruit yearling males (Braun 1986, pp. 229-230; Remington and Braun 1991, pp. 131-132). New leks formed farther from mining disturbance (Remington and Braun 1991, p. 131). Additionally, some leks that were abandoned adjacent to mine areas were reestablished when mining activities ceased, suggesting disturbance rather than habitat loss was the limiting factor (Remington and Braun 1991, p.132). Hen survival did not decline in a population of sage-grouse near large surface coal mines in northeast Wyoming, and nest success appeared not to be affected by adjacent mining activity (Brown and Clayton 2004, p. 1). However, the authors concluded that continued mining would result in fragmentation and eventually impact sage-grouse persistence if adequate reclamation was not employed (Brown and Clayton 2004, p.16).

Mining and associated activities create an opportunity for invasion of exotic and noxious weed species that alter suitability for sage-grouse (Moore and Mills 1977, pp. 125, 129). Reclamation is required by State and Federal laws, but laws generally allow for a change in post-mining land use. Restoration of sagebrush is difficult to achieve and disturbed sites may never return to suitability for sage-grouse (refer to Habitat Description and Characteristics section).

Surface coal mining and associated activities have negative short-term impacts on sage-grouse numbers and habitats near mines (Braun 1998, p. 143). Sage-grouse will reestablish on mined areas once mining has ceased, but there is no evidence that population levels will reach their previous size, and any population reestablishment could take 20 to 30 years based on observations of disturbance in oil and gas fields (Braun 1998, p. 144). Local sage-grouse populations could decline if several leks are affected by coal mining, but the loss of one or two leks in a regional area was likely not limiting to local populations in the Caballo Rojo Mine in northeastern Wyoming based on the presence of viable habitat elsewhere in the region (Hayden-Wing Associates 1983, p. 81). Mining and the associated activities are threats to this species resulting in local habitat loss and fragmentation with associated population reductions.

Renewable Energy Sources

Electricity production from renewable sources increased from 6.4 quadrillion British thermal units (Btu) in 2005 to 7.3 quadrillion Btu by the end of 2008 (EIA 2009d, entire). Wind, geothermal, solar and biomass are renewable energy sources developable in sage-grouse habitats. The renewable energy industry is expected to grow based on legislative mandates to achieve target levels of renewable-produced electricity in many States within the sage-grouse range.

<u>Wind</u>

Wind generating facilities have increased in size and number, outpacing development of other renewable sources in the sage-grouse range. The BLM, the major land manager in the sage-grouse range, developed programmatic guidance to facilitate the use of BLM land for wind development (BLM 2005a, entire). The BLM wind policy permits granting private right-of-ways and leasing of public land for 3-year monitoring and testing facilities and long-term (30 to 35 years) commercial generating facilities (American Wind Energy Association (AWEA) 2008, p. 4-24). Active leases for wind energy development on BLM lands increased

from 9.7 km2 (3.7 mi2) in 2002 to 5,113 km2 (1,973 mi2) in 2008, and an additional 5,381 km2 (2,077 mi2) of lease requests were pending approval in the sage-grouse range (Knick et al., 2011, p. 241).
Areas of commercially viable wind generation have been identified by the NREL (2008b, entire) and BLM (2005a, p. 2.4) in all 11 States in the greater sage-grouse range. Wind harvesting potentials are more concentrated and geographically extensive in sage-grouse MZs I and II that include parts of Montana, Wyoming, North Dakota, and South Dakota; areas of highest commercial potential include 59 percent of the available sagebrush habitats in these four States. MZs III through VII each have approximately 1 to 14 percent of sagebrush habitats that are commercially developable for wind energy (Service 2008e, entire). In total, over 30 percent of the sagebrush lands in the sage-grouse range have high potential for wind power (Table 4).

TABLE 4. Area of Sagebrush Habitat with Wind Energy Development Potential by MZ. Data from Service 2008e)

	Area of Sagebrush with Developable Wind Potential		
SAGE-GROUSE MZ	km^2	mi^2	Percent of MZ
I	137,733	53,179	76.02
II	46,835	18,083	42.16
III	3,028	1,169	3.23
IV	12,952	5,001	9.05
V	5,532	2,136	8.27
VI	2,660	1,027	14.44
VII	199	77	1.10
TOTAL	208,939	80,672	33.02

Commercial viability is based on wind intensity and consistency, available markets and access to transmission facilities. Consequently, current development is focused in areas with existing power transmission infrastructure associated with urban development, preexisting conventional energy resource development (e.g., coal and natural gas) and power generation. Growth of wind power development is expected to continue even in the current economic climate (EIA 2009b, p. 3), spurred by statutory mandates or financial incentives to use renewable energy sources in all 11 States in the range (Association of Fish and Wildlife Agencies (AFWA) and Service 2007, pp. 7, 8, 14, 28, 30, 36, 39, 43, 46, 49, 52; State of Oregon 2008, entire).
A recent increase in wind energy development is most notable within the range of the south-central Wyoming

subpopulation of greater sage-grouse in MZ II where 1,387 km2 (535 mi2) have active wind leases and an additional 2,828 km2 (1,092 mi2) are pending (Knick et al., 2011, p. 241). The south-central Wyoming greater sage-grouse subpopulation has a loose association with adjacent populations where there is accelerated oil, gas, and coal development in the State – the Powder River Basin (MZ I) to the northeast and Pinedale-Jonah Gas Fields in the southwest Wyoming Basin (MZ II) (Connelly et al. 2004, p. 6-62). As stated previously, the Powder River Basin is home to an important regional population of the larger Wyoming Basin populations (Connelly et al. 2004, p. 6-62). The subpopulation in southwest Wyoming and northwest Colorado is a stronghold for sage-grouse with some of the highest estimated densities of males anywhere in the remaining range of the species (Connelly et al. 2004, pp. 6-62, A5-23). The south-central Wyoming wind potential corridor is not only a geographical bridge between two important population areas but is home to a large population of sage-grouse (Connelly et al. 2004, p. A5-22) and core areas identified preliminarily as high density breeding areas for sage-grouse by the Wyoming State Governor's Executive Order (State of Wyoming 2010, entire). Wind development has been recommended for exclusion from core areas in Wyoming, although regulatory mechanisms are still in development (see regulatory mechanisms section below). Twenty-one percent of Wyoming core areas have high wind development potential, and 51 percent are subject to either wind or authorized development of oil and gas leases (Doherty et al., 2011, p. 513).

In addition to Wyoming, southeastern Oregon is a focus area for potential commercial-scale wind development. Currently, south-central and southeastern Oregon have large areas of relatively un-fragmented sage-dominated landscapes which are important for maintaining long-term connectivity between the sage-grouse populations (Knick and Hanser, 2011, p. 383.). The Northern Great Basin ranks lowest of the MZs in the intensity of the human footprint and consequent effects (Leu and Hanser, 2011, p. 267; Wisdom et al., 2011, p. 465), and this could be contributing to the substantial connectivity that still exists between the Northern Great Basin, Snake River Plain, and the Southern Great Basin Region populations (Knick and Hanser, 2011, p. 383). The BLM is the major land manager in this part of the southeastern Oregon, with jurisdiction over 49,000 km2 (18,900 mi2) (BLM 2009d, entire) that include much of the scantily vegetated ridge tops prone to high and sustained wind. At this time, most of the development activity is in the initial phase of meteorological site investigation and involves little infrastructure (AWEA 2009, entire; BLM 2009e). Many of these monitoring sites could be developed, considering the projected demand for renewable energy, contributing to fragmentation of this relatively intact sagebrush landscape.

Most published reports of the effects of wind development on birds focus on the risks of collision with towers or turbine blades. No published research is specific to the effects of wind farms on the greater sage-grouse. However, the avoidance of human-made structures such as powerlines and roads by sage-grouse and other prairie grouse is documented (Holloran 2005, p. 1; Pruett et al., 2009, p. 6). Renewable energy facilities, including wind power, typically require many of the same features for construction and operation as do nonrenewable energy resources. Therefore, we anticipate that potential impacts from direct habitat losses, habitat fragmentation through roads and powerlines, noise, and increased human presence (Connelly et al. 2004, pp. 7-40 to 7-41) will generally be similar to those already discussed for nonrenewable energy development.

Wind farm development begins with site monitoring and collection of meteorological data to accurately characterize the wind regime. Turbines are installed after the meteorological data indicate the appropriate siting and spacing. Roads are necessary to access the turbine sites for installation and maintenance. Each turbine unit has an estimated footprint of 0.4 to 1.2 ha (1 to 3 ac) (BLM 2005a, pp. 3.1-3.4). Turbines require careful placement within a field to avoid loss of output from interference with neighboring turbines. Spacing improves efficiency but expands the overall footprint of the field. One or more substations may be constructed depending on the size of the farm. Substation footprints are 2 ha (5 ac) or less in size (BLM 2005a, p. 3.7). Sage-grouse populations can be impacted by the direct loss of habitat, primarily from construction of access roads as well as indirect loss of habitat due to avoidance.

Sage-grouse could be killed by flying into turbine rotors or towers (Erickson et al. 2001, entire) although reported collision mortalities have been few. No deaths of gallinaceous birds were reported in a comprehensive review of avian collisions and wind farms in the United States; the authors hypothesized that the average tower height and flight height of grouse, and diurnal migration habitats of some birds minimized the risk of collision (Johnson et al. 2000, pp. ii-iii; Erickson et al. 2001, pp. 8, 11, 14, 15). One sage-grouse was found dead within 45 m (148 ft) of a turbine on the Foote Creek Rim wind facility in south-central Wyoming, presumably from flying into a turbine (Young et al. 2003, Appendix C, p. 61). This is the only known sage-grouse mortality at this facility during three years of monitoring. Monitoring has subsequently ceased at this facility. Other mortalities have been recorded at three additional wind facilities in Wyoming (WEST 2010a, in litt.; WEST 2010b; in litt.; Hayes 2011, in litt.), including one apparently resulting from a sage-grouse colliding with wires supporting a meteorological tower (Duke Energy 2010, in litt.). Many wind development facilities are not monitored for avian fatalities, or monitoring is so infrequent that any fatalities may not be detected due to scavenging or decomposition (WEST 2010a, in litt.). Therefore, sage-grouse mortalities from collisions with turbines or appurtenant facilities may be under-estimated.

Research on the use of wind facilities and surrounding areas by sage-grouse is just being initiated at most locations. Studies in Wyoming suggest that use of wind development areas by sage-grouse declines during construction of the facility (WEST 2010a, in litt.; WEST 2010b, in litt.). Additionally, pellet densities for sage-grouse have been less near wind turbines than those for paired reference areas (Enercon 2010, in litt.; WEST 2010a, in litt.) However, the authors caution that these data are preliminary and additional data are needed before definitive conclusions can be made about the use of wind development facilities by sage-grouse. Sage-grouse hens with broods have been observed under turbines at Foote Creek Rim (Young 2004, pers. comm.).

Noise is produced by wind turbine mechanical operation (gear boxes, cooling fans) and airfoil interaction with the atmosphere. No published studies have focused specifically on the effects of wind power noise and greater sage-grouse. In studies conducted in oil and gas fields, noise may have played a factor in habitat selection and decrease in lek attendance (Holloran 2005, pp. 49, 56). However, comparison between wind turbine and oil and gas operations is difficult based on the character of sound. Adjusting for manufacturer type and atmospheric conditions, the audible operating sound of a single wind turbine has been calculated as the same level as conversational speech at 1 m (3 ft) at a distance of 600 m (2,000 ft) from the turbine. This level is typical of background levels of a rural environment (BLM 2005a, p. 5-24). However, commercial wind farms do not have just a single turbine, and multiple turbines over a large area would likely have a much larger noise print. Low-frequency vibrations created by rotating blades produce annoyance responses in humans (van den Berg 2004, p. 1), but the specific effect on birds is not documented. Moving blades of turbines cast moving shadows that cause a flickering effect producing a phenomenon called “shadow flicker” (AWEA 2008, p. 5-33). Hypothetically, shadow flicker could mimic predator shadows and elicit an avoidance response in birds during daylight hours, but this potential effect has not been investigated.

Since 2005, states have required an increasing amount of energy to come from renewable sources. For example, Colorado law requires incremental increases of renewable generation from 3 percent in 2007 to 20 percent by 2020 (AFWA and Service 2007, p. 8). Financial incentives, including grants and tax breaks, encourage private development of renewable sources. Siting authority for wind varies from State to State (AFWA and Service 2007, pp. 7, 8, 14, 28, 30, 36, 39, 43, 46, 49, 52; State of Oregon 2008, entire). For example, the State of Idaho provides tax incentives and loan programs for renewable energy development, but wind power is currently unregulated at any level of government (AFWA and Service 2007, p. 14). The North Dakota Public Service Commission regulates siting of wind power facilities over 100 megawatts using the Service’s interim voluntary guidelines (Service 2003, entire). In Wyoming large construction projects in the State are subject to approval by an Industrial Siting Council (ISC) of the State Department of Environmental Quality with the WGFD providing recommendations for mitigating impacts to wildlife associated with development considered by the ISC. The ISC’s review and approval of projects is subject to the Wyoming Governor’s executive order (State of Wyoming 2010, entire) that is intended to prevent harmful effects to sage-grouse from development or new land uses in designated core areas. Wind development proposed in core areas is unlikely to be permitted by the ISC due to the Governor’s Executive Order.

The BLM manages more land areas of high wind resource potential than any other land management agency. In 2005, the BLM completed the Wind Energy Final Programmatic EIS that provides an overarching guidance for wind project development on BLM-administered lands (BLM 2005a, entire). Best management practices (BMPs) are prescribed to minimize impacts of all phases of construction and operation of a wind production facility, but do not guarantee protections specific to sage-grouse. The BLM indicates that approximately 600 km2 (232 mi2) of BLM-administered lands are likely to be developed in nine States within the sage-grouse's range before 2025 (BLM 2005a, pp. ES-8, 5-2). It is estimated that only 5 to 10 percent of a development will have a long-term disturbance that remains on the landscape for at least as long as the generating facility is viable (i.e., roads, foundations, substation, fencing) (BLM 2005a, p. 5-2). However, this estimate does not account for sage-grouse avoidance of developed areas and could be an underestimation of indirect effects. Based on what we know of oil and gas development (previously described), the impact of structures, noise and human activity can reach far beyond the point of origin and contribute cumulatively to other human-made and natural disturbances that fragment and decrease the quality of sage-grouse habitats. The BLM's determination of the quantity of lands potentially impacted by wind energy development could be extremely conservative considering the interest in reducing green-house emissions and the institution of State renewable energy mandates and incentives that have occurred since 2005.

Wind energy resources are found throughout the range of the greater sage-grouse, and growth of wind power development is expected to continue. The DOE predicts that wind may provide a significant portion of the nation's energy needs by the year 2030, and substantial growth of wind developments will be required (DOE 2008, p. 1). In mid-2009, wind energy production facilities in the sage-grouse range in operation or under construction had a capacity of 11.93 gigawatts (AWEA 2009, entire) (Table 5). To achieve predicted levels of 49 to greater than 90 gigawatts capacity (DOE 2008, p. 10), the generation capacity will need to increase by 400 to 800 percent by 2030. Existing commercial wind turbines range from 1-2 megawatt generating capacity (AWEA 2009, entire). The forecasted increase in production would require approximately 37,000 to 78,000 or more turbines based on the existing technology and equipment in use. Assuming a generation capacity of 5 megawatts per km2 (0.4 mi2) density, Copeland et al. (2009, p. 1) estimated an additional 50,000 km2 (19,305 mi2) of land in the sage-grouse range would be required to meet the predicted level of wind-generated electricity by 2030.

Table 5. Wind energy development in the greater sage-grouse range, 2009-2030.

STATE	MZ	Existing Capacity 2009* (gigawatts)	Forecasted Capacity in 2030 (gigawatts)**
North Dakota	I	1.2	1 to 5
South Dakota	I	0.31	5 to 10
Montana	I	0.17	5 to 10
Wyoming	I, II	1.3	10 plus
Utah	II, III, IV, VII	0.4	1 to 5
Idaho	IV	0.15	1 to 5
Nevada	III, IV, V	0	5 to 10
California	III, V	2.8	10 plus
Oregon	IV, V	2.2	5 to 10
Washington	VI	2.2	5 to 10
Colorado	II, VII	1.2	1 to 5
Total		11.93	49 to 90 plus

*Includes completed and under construction, Source: American Wind Energy Assn. (2009, entire).
** Source: DOE (2008, p. 10).
(1000 megawatt = 1 gigawatt)

We stated in our 2010 status review that Nevada had not been tapped for extensive wind power development, but was likely to experience significant new energy development within the next 20 years (Table 5). The Nevada Division of Wildlife (NDOW) now reports(?) that five wind facilities in sage-grouse habitat have subsequently been proposed. Four of these facilities, if developed as proposed, are likely to have significant impacts on important sage-grouse seasonal habitats (NDOW 2011, in litt.). In Idaho, 24 commercial wind developments are either proposed or in various stages of permitting (IDFG 2011, in litt.). This includes a large development that straddles the Idaho/Nevada line, in close proximity to the area burned by the 2007 Murphy fires (which burned 263,862 ha (652,016 ac), much of which was good sage-grouse habitat). When fully developed, this facility will impact 9,105 ha (22,500 ac) of sage-grouse habitat, with the estimated loss of 24 leks. The BLM states that the project will have long-term adverse effects on both local and regional sage-grouse populations and further contribute to the downward trend in population numbers (BLM 2011, in litt.). In Wyoming, where wind development is advancing and predicted to increase by 10 fold or more (Table 5), the effects of both conventional and nonconventional renewable sources may claim a substantial toll on sage-grouse habitats and geographic areas that were in the past considered refugia for the species. As with oil and gas development, the average footprint of a turbine unit is relatively small from a landscape perspective, but the effects of large-scale developments have the potential to reduce the size of sagebrush habitats directly, degrade habitats with invasive species, provide pathways for synanthropic predators (i.e., predators that live near and benefit from an association with humans), and cumulatively contribute to habitat fragmentation.

Other Renewable Energy Sources

Hydropower development can cause direct habitat losses and possibly an increase in human recreational activity. Reservoirs created concurrently with power generation structures inundated large areas of riparian habitats used by sage grouse broods (Braun 1998, p. 144). Reservoirs and the availability of irrigation water precipitated conversion of large expanses of upland shrub steppe habitat in the Columbia Basin adjacent to the rivers (65 FR 51578). With the exception of one preliminary permit for a pump storage facility in Idaho (IDFG 2011, in litt.), we were unable to find any information regarding the amount of sage-grouse habitat affected by hydropower projects in other areas of the species' range beyond the Columbia Basin. No new large-scale facilities have been constructed and hydropower electricity generation has decreased steadily over the past 10 years (EIA 2009d, entire). We do not anticipate that future dam construction will result in large losses of sagebrush habitats.

Between 2005 and the end of 2008, solar electricity generation increased from the equivalent of 66 trillion Btu to 83 trillion Btu (EIA 2009d, entire). Solar energy systems require, depending on local conditions, 1.6 ha (4 ac) to produce 1 megawatt of electricity, and solar energy infrastructure is often ancillary to other development. We are not aware of any investigations reporting the impacts of solar generating facilities on sage-grouse or other gallinaceous birds. Commercial solar generation could produce direct habitat loss (i.e., solar fields completely eliminate habitat), fragmentation, roads, powerlines, increased human presence, and disturbance during facility construction with similar effects to sage-grouse as reported with oil and gas development. No commercial solar plants are operating in sage-grouse habitats at this time. Southern and eastern Nevada, the Pinedale area of Wyoming, and east-central Utah are the areas of the sage-grouse range with good potential for commercial solar development (EIA 2009e, entire). There are a total of 196 ha (484 ac) of active solar leases on BLM property in northern California (MZ IV) and central Wyoming (MZ II) (BLM 2009g, map) in sagebrush habitats within the current sage-grouse range and these leases will likely be developed. The BLM is developing a programmatic EIS for leasing and development of solar energy on BLM lands. The EIS planning period has been extended to analyze the effects of concentrating large-scale development in selected geographic areas including sage-grouse habitats in east-central Nevada and southern Utah (BLM 2009h, entire) because of the considerable administrative and public interest in developing public lands for solar-generated electricity (BLM 2009i, entire). At this time, we do not have enough information available to evaluate the scale of future impacts of solar power generation in sage-grouse habitats. We will continue to evaluate and monitor the impacts of solar power development in sage-grouse habitats as more information becomes available.

Geothermal energy production has remained steady since 2005 (EIA 2009d, entire). Geothermal facilities are within the sage-grouse range in California (3 plants, MZ III), Nevada (5 plants, MZs III and V), Utah (2 plants, MZ III), and Idaho (1 plant, MZ IV). Since 2005, two additional plants were constructed in current sage-grouse range – one in Idaho and one in Utah (Geothermal Energy Association 2008, pp. 2-7). Another plant in sage-grouse habitats in Nevada has been permitted, but construction has not started (NDOW 2011, in litt.). Three geothermal facilities are proposed in sage-grouse habitats Idaho, but no information regarding the size of these plants was provided (IDFG 2011, in litt.). One existing geothermal plant in southern Utah is in the vicinity of sage-grouse habitat in an area where wind power is being considered for development (First Wind-Milford 2009, entire), which will result in cumulative impacts. Geothermal potential occurs across the sage-grouse range in States with existing development and southeast Oregon, west-central Wyoming, and north-central Colorado (EIA 2009e, entire).

Geothermal energy production is similar to oil and gas development. The ultimate number of wells, and therefore potential loss of habitat, depends on the thermal output of the well and expected production of the plant (Suter 1978, p. 3). Pipelines are needed to carry steam or superheated liquids to the generating plant which is similar in size to a coal- or gas-fired plant, resulting in further habitat and indirect disturbance. Direct habitat loss occurs from well pads, structures, roads, pipelines and transmission lines, and impacts would be similar to those described previously for oil and gas development. Development of geothermal energy requires intensive human activity during field development and operation. Geothermal plants could be in remote areas necessitating housing construction, transportation and utility infrastructure for employees and their families (Suter 1978, p. 12). Geothermal development could cause toxic gas release; the type and effect of these gases depends on the geological formation in which drilling occurs (Suter 1978, pp. 7-9). The amount of water necessary for drilling and condenser cooling may be high. Local water depletions may be a concern if such depletions result in the loss of brood-rearing habitat.

The BLM has the authority to lease geothermal resources in 11 western States. A programmatic EIS for geothermal leasing and operations was completed in 2008 (BLM and USFS 2008a, entire). Best management practices for minimizing the effects of geothermal development and operations on sage-grouse are guidance only and are general in nature (BLM and USFS 2008a, pp. 4.82-4.83). The EIS' reasonably foreseeable development scenario predicts that Nevada will experience the greatest increase in geothermal growth–doubling the production of electricity from geothermal sources by 2025 (BLM and USFS 2008a, p. 2-35). Currently, approximately 1,800 km2 (694 mi2) of active geothermal leases exist on public lands primarily in the Southern (MZ IV) and Northern Great Basin (MZ III) and 1,138 km2 (439 mi2) of leases are pending (Knick et al., 2011, p. 241).

Energy production from biomass sources has increased every year since 2005 (EIA 2009d, entire). Wood has been a primary biomass source, but corn ethanol and biofuels produced from cultivated crops are on the increase (EIA 2008b, entire). Currently, wood products and corn production do not occur in the range of the sage-grouse in significant quantities (Curtis 2008, p. 7). The National Renewable Energy Laboratory cites potentials for agricultural biomass resources in northern Montana (MZ I), southern Idaho (MZ IV), eastern Washington (MZ VI), eastern Oregon MZ IV), northwest Nevada (MZ V), and southeast Wyoming (MZ II) (NREL 2005, entire). Conversion from native sod to agriculture for the purpose of biomass production could result in a loss of sage-grouse habitat on private lands (see discussion under agriculture above). The 2007 Energy Independence and Security Act mandated incremental production and use through the year 2022 of advanced biofuel, cellulosic biofuel, and biomass-based diesel (P.L. 110-140, section 203) and could provide an incentive to convert native sod or expired CRP lands to biomass crops. The effects on sage-grouse will depend on amount and location of sagebrush habitats developed. The effects of agriculture are discussed in habitat conversion section above.

Energy Development – Summary

Energy development is a significant risk to the greater sage-grouse in the eastern portion of its range (Montana, Wyoming, Colorado, and northeastern Utah – MZs I, II, VII and the northeastern part of MZ III). The primary impacts are the direct effects of energy development on the long-term viability of greater sage-grouse by eliminating habitat, leks, and whole populations and fragmenting some of the last remaining large expanses of habitat necessary for the species' persistence. The intensity of energy development is cyclic and based on many factors including energy demand, market prices, and geopolitical uncertainties. However, continued exploration and development of traditional and nonconventional fossil fuel sources in the eastern portion of the greater sage-grouse range is predicted to continue to increase over the next 20 years (EIA 2009b, p. 109). Greater sage-grouse populations are predicted to decline 7 to 19 percent over the next 20 years due to the effects of oil and gas development in the eastern part of the range (Copeland et al. 2009, p. 4); this decline is in addition to the 45 to 80 percent decline that is estimated to have already occurred range wide (Copeland et al. 2009, p. 4). The risk to sage-grouse from energy development is now beginning to affect other parts of the species range. Development of commercially viable renewable energy–wind, solar, geothermal, biomass–is increasing across the range with focus in some areas already experiencing traditional energy development (EIA 2009b, pp. 3-4; AWEA 2009, entire). In Wyoming, where wind development is advancing and predicted to increase by 10 fold (DOE 2008, p. 10), the effects of both conventional and nonconventional and renewable sources may claim a substantial toll on sage-grouse habitats and geographic areas that were in the past considered refugia for the species. Renewable energy resources are likely to be developed in areas previously untouched by traditional energy development, including areas we did not previously identify in our March 2010 status review. Wind energy resources are being investigated in south-central and southeastern Oregon where large areas of relatively unfragmented sage-dominated landscapes are important for maintaining long-term connectivity within the sage-grouse populations (Knick and Hanser 2011, p. 383.).

Greater sage-grouse populations are negatively affected by energy development activities, even when mitigative measures are implemented (Holloran 2005, pp. 57-60; Walker et al. 2007a, p. 2651). Energy development, particularly high density development, will continue to threaten sage-grouse populations, specifically in the MZs I and II, which contain the greatest numbers of birds throughout their range.

Grazing

Native herbivores, such as pronghorn antelope (Antilocarpo americana), mule deer (Odocoileus hemionus), bison (Bison bison), and other ungulates were present in low numbers on the sagebrush-steppe region prior to European settlement of western States (Osborne 1953, p. 267; Miller et al. 1994, p. 111), and sage-grouse co-evolved with these animals. However, mass extinction of the majority of large herbivores occurred 10,000 to 12,000 years ago (Knick et al. 2003, p. 616; Knick et al., 2011, p. 231). From that period up until European settlement, many areas of sagebrush-steppe still did not support herds of large ungulates and grazing pressure was likely sporadic and localized (Miller et al. 1994, p. 113; Plew and Sundell 2000, p. 132; Grayson 2006, p. 921). Additionally, plants of the sagebrush-steppe lack traits that reflect a history of large ungulate grazing pressure (Mack and Thompson 1982, pp. 757). Therefore, native vegetation communities within the sagebrush ecosystem evolved in the absence of significant grazing presence (Mack and Thompson 1982, p. 768). With European settlement of western States (1860 to the early 1900s), unregulated numbers of cattle, sheep, and horses rapidly increased, peaking at the turn of the century (Oliphant 1968, p. vii; Young et al. 1976, pp. 194-195, Carpenter 1981, p. 106; Donahue 1999, p. 15) with an estimated 19.6 million cattle and 25 million sheep in the West (BLM 2009a, p. 1).

Excessive grazing by domestic livestock during the late 1800s and early 1900s, along with severe drought, significantly impacted sagebrush ecosystems (Knick et al. 2003, p. 616). Long-term effects from this overgrazing, including changes in plant communities and soils, persist today (Knick et al. 2003, p.116). Currently, livestock grazing is the most widespread type of land use across the sagebrush biome (Connelly et al. 2004, p. 7-29); almost all sagebrush areas are managed for livestock grazing (Knick et al. 2003, p. 616; Knick et al., 2011, p. 219).

Although little direct experimental evidence links grazing practices to population levels of greater sage-grouse (Braun 1987, p. 137; Connelly and Braun 1997, p. 231), the impacts of livestock grazing on sage-grouse habitat and on some aspects of the life cycle of the species have been studied. A complete review of those studies can be found in our March 2010 status review (75 FR 13939-13941). Impacts include a loss of cover in nesting and brood-rearing habitats resulting in increased predation; soil compaction which reduces water infiltration rates and increases soil erosion (Braun 1998, p. 147; Dobkin et al. 1998, p. 213), resulting in a change in the proportion of shrub, grass, and forb components; and an increased invasion of exotic plant species that do not provide suitable habitat for sage-grouse through loss of the biological soil crust from trampling (Mack and Thompson 1982, p. 761; Young and Allen 1997, p. 531; Miller and Eddleman 2000, pp. 19,21; Knick et al., 2011, p. 232). Livestock also may compete directly with sage-grouse for food resources (Vallentine 1990, pp.226, 240-241). This impact is particularly important for pre-laying hens, as forbs provide essential calcium, phosphorus, and protein (Barnett and Crawford 1994, p. 117). A hen’s nutritional condition affects nest initiation rate, clutch size, and subsequent reproductive success (Barnett and Crawford 1994, p.117; Coggins 1998, p. 30). Livestock also trample sage-grouse habitat, and sometimes the birds and eggs. Although the effect of trampling at a population level is unknown, outright nest destruction has been documented and the presence of livestock can cause sage-grouse to abandon their nests (Rasmussen and Griner 1938, p. 863; Patterson 1952, p. 111; Call and Maser 1985, p. 17; Holloran and Anderson 2003, p. 309; Coates 2007, p.28). Even temporary flushing of grouse from their nests increases the exposure of the eggs to predation (Coates 2007, p.33). Sage-grouse may be both directly and indirectly affected by the placement of thousands of miles of fences for livestock management purposes (see discussion above under Infrastructure). In addition to direct mortality, indirect impacts of fences include the potential for increased mortality through creation of predator perch sites and predator corridors along fences (particularly if a road is maintained next to the fence), incursion of exotic species along the fencing corridor, and habitat fragmentation (Call and Maser 1985, p. 22; Braun 1998, p. 145; Connelly et al. 2000a, p. 974; Beck et al. 2003, p. 211; Knick et al. 2003, p. 612; Connelly et al. 2004, p. 1-2).

Development of springs and other water sources to support livestock in upland shrub-steppe habitats can artificially concentrate domestic and wild ungulates in important sage-grouse habitats, thereby exacerbating grazing impacts, such as heavy grazing and vegetation trampling, in those areas (Braun 1998, p. 147; Knick et al., 2011, p. 232). Diverting the water sources has the secondary effect of changing the habitat present at the water source before diversion. This impact could result in the loss of either riparian or wet meadow habitat important to sage-grouse as sources of forbs or insects. Water developments for livestock and wild ungulates also could be used as mosquito breeding habitat, and thus have the potential to facilitate the spread of West Nile virus (see discussion under Factor C: Disease and Predation).

Some livestock grazing effects may have positive consequences for sage-grouse. Evans (1986, p. 67) found that sage-grouse used grazed meadows significantly more during late summer than ungrazed meadows because grazing had stimulated the regrowth of forbs. Klebenow (1981, p. 121) noted that sage-grouse sought out and used openings in meadows created by cattle grazing in northern Nevada. Also, both sheep and goats have been used to control invasive weeds (Mosley 1996 as cited in Connelly et al. 2004, p. 7-49; Merritt et al. 2001, p. 4; Olsen and Wallander 2001, p. 30) and woody plant encroachment (Riggs and Urness 1989, p. 358) in sage-grouse habitat.

Extensive rangeland treatment has been conducted by federal agencies and private landowners to improve conditions for livestock in the sagebrush-steppe region. (Connelly et al. 2004, p. 7- 28; Knick et al., 2011, p. 220). By the 1970s, over 2 million ha (5 million ac) of sagebrush are estimated to have been mechanically treated, sprayed with herbicide, or burned in an effort to remove sagebrush and increase herbaceous forage and grasses (Crawford et al. 2004, p. 12). The BLM treated over 1,800,000 ha (4,447,897 ac) from 1940 to 1994, with 62 percent of the treatment occurring during the 1960s (Miller and Eddleman 2000, p. 20). Braun (1998, p. 146) concluded that, since European settlement of western North America, all sagebrush habitats used by greater sage-grouse have been treated in some way to reduce shrub cover. Crawford et al. (2004, p. 12) hypothesized that reductions in sage-grouse habitat quality (and possibly sage-grouse numbers) in the 1970s may have been associated with intensive rangeland treatments to increase forage for domestic livestock.

Greater sage-grouse response to herbicide treatments depends on the extent to which forbs and sagebrush are killed. Chemical control of sagebrush has resulted in declines of sage-grouse breeding populations through the loss of live sagebrush cover (Connelly et al. 2000a, p. 972). Herbicide treatment also can result in sage-grouse emigration from affected areas (Connelly et al. 2000a, p. 973), and has been documented to have a negative effect on nesting, brood carrying capacity (Klebenow 1970, p. 399), and winter shrub cover essential for food and thermal cover (Pyrah 1972 and Higby 1969 as cited in Connelly et al. 2000a, p. 973). Conversely, small treatments interspersed with non-treated sagebrush habitats did not affect sage-grouse use, presumably due to minimal effects on food or cover (Braun 1998, p. 147). Application of herbicides in early spring to reduce sagebrush cover may enhance some brood-rearing habitats by increasing the coverage of herbaceous plant foods (Autenrieth 1981, p. 65).

Mechanical treatments are designed to either remove the aboveground portion of the sagebrush plant (mowing, roller chopping, and roto-beating), or to uproot the plant from the soil (grubbing, bulldozing, anchor chaining, cabling, railing, raking, and plowing; Connelly et al. 2004, p. l7-47). These treatments were begun in the 1930s and continued at relatively low levels to the late 1990s (Braun 1998, p. 147). Mechanical treatments, if carefully designed and executed, can be beneficial to sage-grouse by improving herbaceous cover, forb production and sagebrush re-sprouting (Braun 1998, p. 147). However, adverse effects also have been documented (Connelly et al. 2000a, p. 973). For example, in Montana, the number of breeding males declined by 73 percent after 16 percent of the 202 km2 (78 mi2) study area was plowed (Swenson et al. 1987, p. 128). Research conducted in north-central Wyoming found that mowing was more likely than prescribed fire to retain sagebrush canopy cover and insect diversity, but that mowing did not promote an increase in forbs, perennial grass canopy cover, or abundance or weights of beetles and grasshoppers (Hess and Beck 2010, p. 51). Mechanical treatments in blocks greater than 100 ha (247 ac), or of any size seeded with exotic grasses, degrade sage-grouse habitat by altering the structure and composition of the vegetative community (Braun 1998, p. 147).

Historically, the elimination of sagebrush followed with rangeland seedings was encouraged to improve forage for livestock grazing operations (Blaisdell 1949, p. 519). Large expanses of sagebrush removed via chemical and mechanical methods have been reseeded with nonnative grasses, such as crested wheatgrass (Agropyron cristatum), to increase forage production on public lands (Pechanec et al. 1965 as cited in Connelly et al. 2004, p.7-28). These treatments reduced or eliminated many native grasses and forbs present prior to the seedings (Hull 1974, p. 217). Sage-grouse are affected indirectly through the loss of native forbs that serve as food and loss of native grasses that provide concealment or hiding cover (Connelly et al. 2004, p. 4-4).

As described previously in the section on fire, land managers use prescribed fire to obtain desired management objectives for a variety of wildlife species and domestic ungulates in sagebrush habitats throughout the range of the greater sage-grouse (Knick et al. 2003; p. 616; Hess and Beck 2010, p. 3). The immediate and potentially long-term result for greater sage-grouse is the loss of habitat (Beck et al. 2009, p. 400). Knick et al. (2011, p. 224) report that over 370,000 ha (914,000 ac) of public lands were treated with prescribed fire to address management objectives for many different species between 1997 and 2006, mostly in Oregon and Idaho. However, these acreages represent all habitat types and thus over-estimate negative impacts to greater sage-grouse. Between 2003 and 2008, approximately 133,500 ha (330,000 ac) of greater sage-grouse habitat have been burned by land managers within the DOI or approximately 22,000 ha (55,000 ac) annually. This acreage does not reflect lands burned by agencies under the USDA (e.g., USFS). Prescribed fire is often used to specifically enhance habitat conditions for sage-grouse (Hess and Beck 2010, p. 21, and references therein; Erickson 2011, p. 45 and references therein). While fire may increase short-term perennial grass and forb production in mountain big sagebrush (Hess and Beck 2010, p. 21), the benefits to sage-grouse populations are questionable (Peterson 1970, p. 154; Swensen et al. 1987, p. 128; Connelly et al. 2000c, p. 94; Nelle et al. 2000, p. 590; WAFWA 2009, p. 12; Hess and Beck 2010, p.54; Rhodes et al. 2010, p.763; Erickson 2011, p. 77; Connelly et al. 2011, p. 63). For example, in Idaho, male lek attendance and number of active leks declined 5 years after burning at greater levels in than in a control area (Beck et al. 2009, p. 394). No difference was detected in soil characteristics (total nigrogen and total carbon) between burned and unburned sites in north-central Wyoming (Hess and Beck 2010, p. 47), which was also reflected in the lack of differences in the nutritional quality of sage-grouse food forbs between those areas (Hess and Beck 2010, p. 49). Burning to improve brood-rearing habitats in Wyoming actually adversely affected these habitats based on sage-grouse use of these areas (Erickson 2011, p. 72). The benefits resulting from increased forb production within burns appeared to be completely negated by the loss of shrub cover (Erickson 2011, p. 78). Many authors also recommend caution in using fire for sage-grouse habitat improvement projects due to the potential for the incursion of annual grasses such as Bromus tectorum (Baker 2006, p. 183; Beck et al. 2009, p. 399; Hess and Beck 2010, p. 53; Baker 2011, p. 200).

The current extent to which mechanical, chemical, and prescribed fire methods are used to remove or control sagebrush is not known, particularly with regard to private lands. However, BLM has stated that with rare exceptions, they no longer are involved in actions that convert sagebrush to other habitat types, and that mechanical or chemical treatments in sagebrush habitat on BLM lands currently focus on improving the diversity of the native plant community, reducing conifer encroachment, or reducing the risk of a large wildfire (see discussion of Fire above; BLM 2004, p. 15). However, the preferred alternative presented by the Bureau of Land Management in their 1991 Final Vegetation Environmental Impact Statement recommended treating 919 212 ha (2,271,422 ac) in the 13 western states annually (Knick et al. 2003, p. 620).

The NRCS has entered into contracts on 211,860 ha (523516 ac) of private lands to change grazing systems to provide increased hiding cover for sage-grouse (NRCS 2011, in litt.). As the new systems have only been implemented on 3,983 ha (9,842 ac) at this time, we are unable to accurately assess the benefit of these contracts at this time. Additionally, the NRCS is also conducting research to determine the effects of their grazing systems in central Montana (NRCS 2011, in litt.). The results of this work will not be completed for several years.

The impacts of livestock operations on sage-grouse depend upon stocking levels, season of use, utilization levels and on the condition of the habitat. Thus, the effects of livestock grazing vary across the range of the greater sage-grouse. For example, Aldridge and Brigham (2003, p. 30) suggest that poor livestock management in mesic sites, which are considered limited habitats for sage-grouse in Alberta (Aldridge and Brigham 2002, p. 441), results in a reduction of forbs and grasses available to sage-grouse chicks, thereby affecting chick survival. Cattle and sheep Animal Unit Months (AUMs) (the amount of forage required to feed one cow with calf, one horse, five sheep, or five goats for 1 month) on all Federal land have declined since the early 1900s (Laycock et al. 1996, p. 3). By the 1940s, AUMs on all Federal lands (not just areas occupied by sage-grouse) were estimated to be 14.6 million, increasing to 16.5 million in the 1950s, and gradually declining to 10.2 million by the 1990s (Miller and Eddleman 2000, p. 19). Although AUMs have decreased over time, we cannot assume that the net impact of grazing has decreased because the productivity of those lands has decreased (Knick et al., 2011, p. 232). As of 2007, the number of permitted AUMs for BLM lands in States where sage-grouse occur totaled 7,118,989 (Beever and Aldridge, 2011, p. 287). We estimate that those permitted AUMs occur in approximately 18,783 BLM grazing allotments in sage-grouse habitat (USFWS 2008a). Since 2005, 644 (3.4 percent) of those allotments have decreased the permitted AUMs (Service 2008a). However, BLM tracks the number of AUMs permitted rather than the number of AUMs actually used. As the number permitted typically is higher than what is used, we do not know how the decrease on paper corresponds to the actual number of AUMs.

Grazing has changed the functioning of sagebrush plant systems into less resilient, and in some cases, altered communities (Knick et al., 2011, p. 231). The ability to restore or rehabilitate areas depends on the condition of the area relative to its site potential (Cagney et al. 2010, p. 13; Knick et al., 2011, pp. 232-233). For example, if an area has a balanced mix of shrubs and native understory vegetation, a change in grazing management can restore the habitat to its potential vigor (Pyke, 2011, p. 538). Active restoration would be required where native understory vegetation is much reduced (Pyke, 2011, p. 539). But, if an area has soil loss and/or invasive species, returning the site to the native historical plant community may be impossible (Daubenmire 1970, p. 82; Knick et al., 2011, p. 231; Pyke, 2011, p. 539). Aldridge et al. (2008, p. 990) did not find any relationship between sage-grouse persistence and livestock densities. However, the authors noted that livestock numbers do not necessarily correlate with range condition. They concluded that the intensity, duration and distribution of livestock grazing are more influential on rangeland condition than the livestock density values used in their modeling efforts (Aldridge et al. 2008, p. 990).

Wild Horse and Burro Grazing

Free-roaming horses and burros have been a component of sagebrush and other arid communities since they were brought to North America at the end of the 16th century (Wagner 1983, p. 116; Beever 2003, p. 887). About 38,400 wild horses and burros occur in 10 western States (including 2 states outside the range of the greater sage-grouse; Abbey in litt. 2010), with herd sizes being largest in Nevada, Wyoming, and Oregon, which are the States with the most extensive sagebrush cover (Connelly et al. 2004, p. 7-37). The number of feral horses and burros is nearly 12,000 animals (44 percent) over what is sustainable (Jeffress and Roush 2010, in litt.). Beever and Aldridge (2011, p. 278) estimate that about 12 percent (78, 389 km2, 30,266 mi2) of sage-grouse habitat is managed for free-roaming horses and burros. However, the extent to which the equids use land outside of designated management areas is difficult to quantify but may be considerable.

We are unaware of any studies that directly address the impact of wild horses or burros on sagebrush and sage-grouse. The overpopulation of feral equids on federal lands is resulting in depleted forage and water, loss of vegetation and habitat disturbance (Jeffress and Roush 2010, in litt.). Some authors have suggested that wild horses could negatively impact important meadow and spring brood-rearing habitats used by sage-grouse (Crawford et al. 2004, p. 11; Connelly et al. 2004, p. 7-37). Horses are generalists, but seasonally their diets can be almost wholly comprised of grasses (Wagner 1983, pp. 119-120). A comparison of areas with and without horse grazing showed 1.9 to 2.9 times more grass cover and higher grass density in areas without horse grazing (Beever et al. 2008 as cited Beever and Aldridge 2011, p. 282). Additionally, sites with horse grazing had less shrub cover and more fragmented shrub canopies (Beever and Aldridge 2011, p. 282). Sites with grazing also generally showed less plant diversity, altered soil characteristics, and 1.6 to 2.6 times greater abundance of nonnative Bromus tectorum (Beever et al. 2008 as cited in Beever and Aldridge 2011, p. 283). These impacts combined indicate that horse grazing has the potential to result in an overall decrease in the quality and quantity of sage-grouse habitat in areas where such grazing occurs.

Currently, free-roaming equids consume an estimated 315,000 to 433,000 AUMs as compared to over 7 million AUMs for domestic livestock within the range of greater sage-grouse (Beever and Aldridge, 2011, p. 286). There are significant biological and behavioral differences that influence the impact of horses as compared to cattle grazing on habitat (Beever 2003, pp. 888-890). For example, due to physiological differences, a horse must forage longer and consumes 20 to 65 percent more forage than would a cow of equivalent body mass (Wagner 1983, p. 121; Menard et al. 2002, p.127). Unlike cattle and other ungulates, horses can crop vegetation close to the ground, potentially limiting or delaying recovery of plants (Menard et al. 2002, p.127). In addition, horses seasonally move to higher elevations, spend less time at water, and range farther from water sources than cattle (Beever and Aldridge 2011, p. 286). Given these differences, along with the confounding factor of past range use, it is difficult to assess the overall magnitude of the impact of horses on the landscape in general, or on sage-grouse habitat in particular. In areas grazed by both horses and cattle, whether the impacts are synergistic or additive is currently unknown (Beever and Aldridge, 2011, p. 286).

Wild ungulate herbivory

Native herbivores, such as elk (Cervus elaphus), mule deer, and pronghorn antelope coexist with sage-grouse in sagebrush ecosystems (Miller et al. 1994, p. 111). These ungulates are present in sagebrush ecosystems during various seasons based on dietary needs and forage availability (Kufeld 1973, p. 106-107; Kufeld et al. 1973 as cited in Wallmo and Regelin 1981, p. 387-396; Allen et al. 1984, p. 1). Elk primarily consume grasses but are highly versatile in consumption of forbs and shrubs when grasses are not available (Kufeld 1973, pp. 106-107; Vallentine 1990, p. 235). In the winter, heavy snow forces elk to lower-elevation sagebrush areas where they forage heavily on sagebrush (Wambolt and Sherwood 1999, p. 225). Mule deer utilize forbs, shrubs and grasses throughout the year dependent upon availability and preference (Kufeld et al. 1973 as cited in Wallmo and Regelin 1981, pp. 389-396). Pronghorn antelope, most commonly associated with grasslands and sagebrush, consume a wide variety of available shrubs and forbs and consume new spring grass growth (Allen et al. 1984, p. 1; Vallentine 1990, p. 236).

We are unaware of studies evaluating the effects of native ungulate herbivory on sage-grouse and sage-grouse habitat. However, concentrated native ungulate herbivory may impact vegetation in sage-grouse habitat on a localized scale. Native ungulate winter browsing can have substantial, localized impacts on sagebrush vigor, resulting in decreased shrub cover or sagebrush mortality (Wambolt 1996, p. 502; Wambolt and Hoffman 2004, p.195). Additionally, despite decreased habitat availability, elk and mule deer populations are currently higher than pre-European estimates (Wasley 2004, p. 3; Young and Sparks 1985, p. 67-68). As a result, some States started small-scale supplemental feeding programs for deer and elk. In those localized areas, vegetation is heavily utilized from the concentration of animals (Doman and Rasmussen 1944, p. 319; Smith 2001, pp. 179-181). Unlike domestic ungulates, wild ungulates are not confined to the same area, at the same time each year. Therefore, the impacts from wild ungulates are spread more diffusely across the landscape, resulting in minimal long-term impacts to the vegetation community.

The Utah Division of Wildlife Resources annually conducts sagebrush removal projects to facilitate the development of understory grasses and forbs for sage-grouse brood-rearing habitats. The method of removal was not identified, and the agency considers these projects to have long-term benefits (UDWR 2011, in litt.). Similarly, the Wyoming Game and Fish Department conducted approximately 1,214 ha (3,000 ac) of sagebrush treatments (using a mosaic design) in 2010, in primarily late brood-rearing habitats. The method of treatment was not identified, but the agency considers the treatments to be positive or neutral for sage-grouse (WGFD 2011, in litt.).

Summary of Grazing

Livestock management and domestic grazing can degrade sage-grouse habitat through loss of concealing vegetation, soil compaction, loss of herbaceous plant abundance, increased soil erosion, and increasing the probability of invasive species. Extensive fencing systems constructed to manage domestic livestock cause direct mortality to sage-grouse in addition to degrading and fragmenting habitats. Livestock management also can involve water developments that can degrade important brood rearing habitat and or facilitate the spread of WNv. Additionally, some research suggests there may be direct competition between sage-grouse and livestock for plant resources. However, although there are obvious negative impacts, some research suggests that under very specific conditions grazing can benefit sage-grouse. Similar to domestic grazing, wild horses and burros have the potential to negatively affect sage-grouse habitats in areas they occur by decreasing grass cover, fragmenting shrub canopies, altering soil characteristics, decreasing plant diversity, and increasing the abundance of invasive Bromus tectorum.

Native ungulates have co-existed with sage-grouse in sagebrush ecosystems. Elk and mule deer browse sagebrush during the winter and can cause mortality to small patches of sagebrush from heavy winter use. Pronghorn antelope, largely overlapping with sage-grouse habitat year around, consume grasses and forbs during the summer and browse on sagebrush in the winter. We are not aware of research analyzing impacts from these native ungulates on sage-grouse or sage-grouse habitat.

Currently there is little direct evidence linking grazing practices to population levels of greater sage-grouse. However, testing for impacts of grazing at landscape scales important to sage-grouse is confounded by the fact that almost all sage-grouse habitat has at one time been grazed and thus no non-grazed, baseline areas currently exist with which to compare (Knick et al. 2011, p. 232). Although we cannot examine grazing at large spatial scales, we do know that grazing can have negative impacts to sagebrush and consequently to sage-grouse at local scales. However, how these impacts operate at large spatial scales and thus on population levels is currently unknown. Given the widespread nature of grazing, the potential for population level impacts cannot be ignored.

Climate Change

The Intergovernmental Panel on Climate Change (IPCC) has concluded that warming of the climate is unequivocal, and that continued greenhouse gas emissions at or above current rates will cause further warming (IPCC 2007, p. 30). Climate-change scenarios estimate that the mean air temperature could increase by over 3°C (5.4°F) by 2100 (IPCC 2007, p. 46). The IPCC also projects that there will very likely be regional increases in the frequency of hot extremes, heat waves, and heavy precipitation (IPCC 2007, p. 46), as well as increases in atmospheric carbon dioxide (IPCC 2007, p. 36).

We recognize that there are scientific differences of opinion on many aspects of climate change, including the role of natural variability in climate. In our analysis, we rely primarily on synthesis documents (e.g., IPCC 2007; Global Climate Change Impacts in the United States 2009) that present the consensus view of a very large number of experts on climate change from around the world. We have found that these synthesis reports, as well as the scientific papers used in those reports or resulting from those reports, represent the best available scientific information we can use to inform our decision and have relied upon them and provided citations within our analysis. In addition, where possible we have used projections specific to the region of interest, the western United States and southern Canada, which includes the range of the greater sage-grouse. We also use projections of the effects of climate change to sagebrush where appropriate, while acknowledging that the uncertainty of climate change effects increases as one applies those potential effects to a habitat variable like sagebrush, and then increases again when the impacts to the habitat variable are applied to the species.

Projected climate change and its associated consequences have the potential to affect greater sage-grouse and may increase its risk of extinction, as the impacts of climate change interact with other stressors such as disease, and habitat degradation and loss that are already affecting the species (Walker and Naugle, 2011, entire; Global Climate Change Impacts in the United States 2009, p. 81; Miller et al. 2011, pp. 174-179). In the Pacific Northwest, regionally averaged temperatures have risen 0.8 degrees Celsius (1.5 degrees Fahrenheit) over the last century (as much as 2 degrees Celsius (4 degrees Fahrenheit) in some areas), and are projected to increase by another 1.5 to 5.5 degrees Celsius (3 to 10 degrees Fahrenheit) over the next 100 years (Mote et al. 2003, p. 54; Global Climate Change Impacts in the United States 2009, p. 135). Arid regions such as the Great Basin where greater sage-grouse occurs are likely to become hotter and drier; fire frequency is expected to accelerate, and fires may become larger and more severe (Brown et al. 2004, pp. 382-383; Neilson et al. 2005, p. 150; Chambers and Pellant 2008, p. 31; Global Climate Change Impacts in the United States 2009, p. 83).

Climate changes such as shifts in timing and amount of precipitation, and changes in seasonal high and low temperatures, as well as average temperatures, may alter distributions of individual species and ecosystems significantly (Bachelet et al. 2001, p174). Under projected future temperature conditions, the cover of sagebrush within the distribution of sage-grouse is anticipated to be reduced (Neilson et al. 2005, p. 154; Miller et al. 2011, p. 179). Warmer temperatures and greater concentrations of atmospheric carbon dioxide create conditions favorable to Bromus tectorum, as described above, thus continuing the positive feedback cycle between the invasive annual grass and fire frequency that poses a significant threat to greater sage-grouse (Chambers and Pellant 2008, p. 32; Global Climate Change Impacts in the United States 2009, p. 83; Schrag et al. 2010, p. 5). Fewer frost-free days also may favor frost-sensitive woodland vegetation of Sonoran and Chihuahuan deserts, which may expand, potentially encroaching on the sagebrush biome in the southern Great Basin where sage-grouse populations currently exist (Miller et al. 2011, p. 176). Such encroachment of woody vegetation degrades sage-grouse habitat (see discussion under Invasive plants). Temperature and precipitation both directly influence potential for West Nile virus (WNv) transmission (Walker and Naugle 2011, p. 131). In sage-grouse, WNv outbreaks appear to be most severe in years with higher summer temperatures (Walker and Naugle 2011, p. 135) and under drought conditions (Epstein and Defilippo, p. 105). This relationship is due to the breeding cycle of the WNv vector, Culex tarsalis, being highly dependent on warm water temperature for mosquito activity and virus amplification (Walker and Naugle 2011, p. 129; see discussion under Disease and Predation below). Therefore, the higher summer temperatures and more frequent or severe drought or both, that are likely under current climate change projections, make more severe WNv outbreaks likely in low-elevation sage-grouse habitats where WNv is already endemic, and also make WNv outbreaks possible in higher elevation sage-grouse habitats that to date have been WNv-free due to relatively cold conditions (Schrag et al. 2010, p. 5).

Emissions of carbon dioxide, considered to be the most important anthropogenic greenhouse gas, increased by approximately 80 percent between 1970 and 2004 due to human activities (IPCC 2007, p. 36). Future carbon dioxide emissions from energy use are projected to increase by 40 to 110 percent over the next few decades, between 2000 and 2030 (IPCC 2007, p. 44). An increase in the atmospheric concentration of carbon dioxide has important implications for greater sage-grouse, beyond those associated with warming temperatures, because higher concentrations of carbon dioxide are favorable for the growth and productivity of Bromus tectorum (Smith et al. 1987, p. 142; Smith et al. 2000, p. 81). Although most plants respond positively to increased carbon dioxide levels, many invasive nonnative plants respond with greater growth rates than native plants, including B. tectorum (Smith et al. 1987, p. 142; Smith et al. 2000, p. 81; Global Climate Change Impacts in the United States 2009, p. 83). Laboratory research results illustrated that B. tectorum grown at carbon dioxide levels representative of current climatic conditions matured more quickly, produced more seed and greater biomass, and produced significantly more heat per unit biomass when burned than B. tectorum grown at “pre-industrial” carbon dioxide levels (Blank et al. 2006, pp. 231, 234). These responses to increasing carbon dioxide may have increased the flammability in B. tectorum communities during the past century (Ziska et al. 2005, as cited in Zouhar et al. 2008, p. 30; Blank et al. 2006, p. 234).

Field studies likewise demonstrate that Bromus species demonstrate significantly higher plant density, biomass, and seed rain (dispersed seeds) at elevated carbon dioxide levels relative to native annuals (Smith et al. 2000, pp. 79-81). The researchers conclude that “the results from this study confirm experimentally in an intact ecosystem that elevated carbon dioxide may enhance the invasive success of Bromus spp. in arid ecosystems,” and suggest that this enhanced success will then expose these areas to accelerated fire cycles (Smith et al. 2000, p. 81). Chambers and Pellant (2008, p. 32) also suggest that higher carbon dioxide levels are likely increasing B. tectorum fuel loads due to increased productivity, with a resulting increase in fire frequency and extent. Based on the best available information, we expect the current and predicted atmospheric carbon dioxide levels to increase the threat posed to greater sage-grouse by B. tectorum and from higher frequency wildfires (Smith et al. 1987, p. 143; Smith et al. 2000, p. 81; Brown et al. 2004, p. 384; Neilson et al. 2005, pp. 150, 156; Chambers and Pellant 2008, pp. 31-32). Therefore, beyond the potential changes associated with temperature and precipitation, increases in carbon dioxide concentrations represent a threat to the sagebrush biome and an indirect threat to sage-grouse through habitat degradation and loss (Miller et al. 2011, p. 179), with the combined effects of higher temperatures and carbon dioxide concentrations leading to a loss of 12 percent of the current area of sagebrush per degree Celsius of temperature increase, or from 34 to 80 percent of sagebrush distribution depending on the emissions scenario used (Nielson et al. 2005, p. 6, 10; Miller et al. 2011, p. 179).

Bradley (2009, pp. 196-208) and Bradley et al. (2009, pp. 1-11) predict that nonnative invasive species in the sagebrush-steppe ecosystem may either expand or contract under climate change, depending on the current and projected future range of a particular invasive plant species. They developed a bioclimatic model for Bromus tectorum based on maps of invaded range derived from remote sensing. The best predictors of B. tectorum occurrence were summer, annual, and spring precipitation, followed by winter temperature (Bradley et al., 2009, p. 5). Depending primarily on future precipitation conditions, the model predicts B. tectorum is likely to shift northwards, leading to expanded risk of B. tectorum invasion in Idaho, Montana, and Wyoming, but reduced risk of invasion in southern Nevada and Utah, which currently have large areas dominated by this nonnative grass (Bradley et al., 2009, p. 5). Therefore, the threat posed to greater sage-grouse by the greater frequency and geographic extent of wildfires and other associated negative impacts from the presence of B. tectorum is expected to continue into the foreseeable future. Bradley (2009, pp. 205) stated that the bioclimatic model she used is an initial step in assessing the potential geographic extent of B. tectorum, because climate conditions only affect invasion on the broadest regional scale. Other factors relating to land use, soils, competition or topography may affect suitability of a given location. Bradley (2009, entire) concludes that the potential for climate to shift away from suitability for B. tectorum in the future may offer an opportunity for restoration of the sagebrush biome in this area. We anticipate that areas that become unsuitable for B. tectorum may transition to other vegetation over time. However, it is not known if transition back to sagebrush as a dominant landcover or to other native or nonnative vegetation is more likely.

In a study that modeled potential impacts to big sagebrush (A. tridentata ssp.) due to climate change, Shafer et al. (2001, pp. 200-215) used response surfaces to describe the relationship between bioclimatic variables and the distribution of tree and shrub taxa in western North America. Species distributions were simulated using scenarios generated by three general circulation models – HADCM2, CGCM1, and CSIRO. Each scenario produced similar results, simulating future bioclimatic conditions that would reduce the size of the overall range of sagebrush and change where sagebrush may occur. These simulated changes were the result of increases in the mean temperature of the coldest month which the authors speculated may interact with soil moisture levels to produce the simulated impact. Each model predicted that climate suitability for big sagebrush would shift north into Canada. Areas in the current range would become less suitable climatically, and would potentially cause significant contraction. The authors also point out that increases in fire frequency under the simulated climate projections would leave big sagebrush more vulnerable to fire impacts.

Shafer et al. (2001, p. 213) explicitly state that their approach should not be used to predict the future range of a species, and that the underlying assumptions of the models they used are “unsatisfying” because they presume a direct causal relationship between the distribution of a species and particular environmental variables. Shafer et al. (2001, pp. 207, 213) identify cautions similar to Bradley et al. (2009, p. 205) regarding their models. A variety of factors are not included in climate space models, including: the effect of elevated CO_2 on the species’ water-use efficiency, what really is the physiological effect of exceeding the assumed (modeled) bioclimatic limit on the species, the life stage at which the limit affects the species (seedling versus adult), the life span of the species, and the movement of other organisms into the species range (Shafer et al., 2001, p. 207). These variables would likely help determine how climate change would affect species distributions. Shafer et al. (2001, p. 213) concludes that while more empirical studies are needed on what determines a species and multi-species distributions, those data are often lacking; in their absence climatic space models can play an important role in characterizing the types of changes that may occur so that the potential impacts on natural systems can be assessed.

Schrag et al. 2010 (entire) developed a bioclimatic envelope model for big sagebrush and silver sagebrush in the States of Montana, Wyoming, and North and South Dakotas. This analysis suggests that large displacement and reduction of sagebrush habitats will occur under climate change as early as 2030 for both species of sagebrush examined. Key remaining areas include southwestern Wyoming and north-central Montana (Schrag et al. 2010, p. 8). The model outputs in their analyses are supported by known historical distributions of sagebrush in relation to climate and paleoecological evidence of historic sagebrush distributions (Schrag et al. 2010, p. 11). The authors caution that their predicted decreases in suitable climatic habitat do not necessarily mean the immediate loss of individuals from the landscape, but only that climatic conditions are less conducive to the long-term survival and reproduction of sagebrush (Schrag et al. 2010, p. 12). They also caution that sagebrush communities may have been a state of change when data were collected for their analyses, and therefore the resulting models are over-estimating sagebrush persistence (Schrag et al. 2010, p. 12). Other models projecting the effect of climate change on sagebrush habitat, discussed below, identify uncertainty associated with projecting climatic habitat conditions into the future given the unknown influence of other factors that such models do not incorporate (e.g., local physiographic conditions, life stage of the plant, generation time of the plant and its reaction to changing CO_2 levels). Models examining the impact of climate change on West Nile virus (WNv), a disease fatal to sage-grouse (see discussion under Disease and Predation section), show that it is likely to spread to higher elevations due to warming temperatures at those locations (Schrag et al. 2010, p. 11). This could result in an expanded distribution of the disease to areas with low current vulnerability due to limited ambient temperatures.

In some cases, effects of climate change can be demonstrated (e.g., McLaughlin et al. 2002) and where it can be, we rely on that empirical evidence, such as increased stream temperatures (see Rio Grande cutthroat trout, 73 FR 27900), or loss of sea ice (see polar bear, 73 FR 28212), and treat it as a threat that can be analyzed. However, we have no such data relating to greater sage-grouse. Application of continental scale climate change models to regional landscapes, and even more local or "step-down" models projecting habitat potential based on climatic factors, while informative, contain a high level of uncertainty due to a variety of factors including: regional weather patterns, local physiographic conditions, life stages of individual species, generation time of species, and species reactions to changing CO2 levels. The models summarized above are limited by these types of factors; therefore, their usefulness in assessing the threat of climate change on greater sage-grouse also is limited.

Summary of Climate Change

The direct, long-term impact from climate change to greater sage-grouse is yet to be determined. However, as described above, the invasion of Bromus tectorum and the associated changes in fire regime currently pose one of the significant threats to greater sage-grouse and the sagebrush-steppe ecosystem. Under current climate-change projections, we anticipate that future climatic conditions will favor further invasion by B. tectorum, as well as woody invasive species that affect habitat suitability, and that fire frequency will continue to increase, and the extent and severity of fires may increase as well. Climate warming is also likely to increase the severity of WNv outbreaks and to expand the area susceptible to outbreaks into areas that are now too cold for the WNv vector. Therefore, the consequences of climate change, if current projections are realized, are likely to exacerbate the existing primary threats to greater sage-grouse of frequent wildfire and invasive nonnative plants, particularly B. tectorum as well as the threat posed by disease. As the IPCC projects that the changes to the global climate system in the 21st century will likely be greater than those observed in the 20th century (IPCC 2007, p. 45), we anticipate that these effects will continue and likely increase into the foreseeable future. As there is some degree of uncertainty regarding the potential effects of climate change on greater sage-grouse specifically, climate change in and of itself was not considered a significant factor in our determination whether greater sage-grouse is warranted for listing. However, we expect the severity and scope of two of the significant threats to greater sage-grouse, frequent wildfire and B. tectorum colonization and establishment; as well as epidemic WNv, to magnify within the foreseeable future due the effects of climate change already underway (i.e., increased temperature and carbon dioxide). Thus, currently we consider climate change as playing a potentially important indirect role in intensifying some of the current significant threats to the species.

Summary of Factor A

Greater sage-grouse are a landscape-scale species requiring large, contiguous areas of sagebrush for long-term persistence. Large-scale characteristics within surrounding landscapes influence habitat selection, and adult sage-grouse exhibit a high fidelity to all seasonal habitats, resulting in little adaptability to changes. Fragmentation of sagebrush habitats has been cited as a primary cause of the decline of sage-grouse populations (Patterson 1952, pp. 192-193; Connelly and Braun 1997, p. 4; Braun 1998, p. 140; Johnson and Braun 1999, p. 78; Connelly et al. 2000a, p. 975; Miller and Eddleman 2000, p. 1; Schroeder and Baydack 2001, p. 29; Johnsgard 2002, p. 108; Aldridge and Brigham 2003, p. 25; Beck et al. 2003, p. 203; Pedersen et al. 2003, pp. 23-24; Connelly et al. 2004, p. 4-15; Schroeder et al. 2004, p. 368; Leu and Hanser 2011, p. 267). Documented negative effects of fragmentation include reduced lek persistence, lek attendance, population recruitment, yearling and adult annual survival, female nest site selection, nest initiation, and loss of leks and winter habitat (Holloran 2005, p. 49; Aldridge and Boyce 2007, pp. 517-523; Walker et al. 2007a, pp. 2651-2652; Doherty et al. 2008, p. 194). Functional habitat loss also contributes to habitat fragmentation as greater sage-grouse avoid areas due to human activities, including noise, even though sagebrush remains intact. In an analysis of population connectivity, Knick and Hanser (2011, p. 404) demonstrated that in some areas of the sage-grouse range, populations are already isolated and at risk for extirpation due to genetic, demographic, and environmental stochasticity. Habitat loss and fragmentation contribute to this population isolation and increased risk of extirpation.

We continue to examine several factors that result in habitat loss and fragmentation. Conversion of sagebrush habitats for agriculture is continuing, and may increase due to the promotion of biofuel production and new technologies to provide irrigation to arid lands. Both direct and indirect habitat loss and fragmentation also has occurred as the result of expanding human populations in the western United States, and the resulting urban development in sagebrush habitats.

Fire is one of the primary factors linked to population declines of greater sage-grouse because of long-term loss of sagebrush and conversion to nonnative grasses. Loss of sagebrush habitat to wildfire has been increasing in the western portion of the greater sage-grouse range due to an increase in fire frequency and size. This change is the result of incursion of nonnative annual grasses, primarily Bromus tectorum, into sagebrush ecosystems. The positive feedback loop between B. tectorum and fires facilitates future fires and precludes the opportunity for sagebrush, which is killed by fire, to become re-established. B. tectorum and other invasive plants also alter habitat suitability for sage-grouse by reducing or eliminating native forbs and grasses essential for food and cover. Annual grasses and noxious perennials continue to expand their range, facilitated by ground disturbances, including wildfire, grazing, agriculture, and infrastructure associated with energy development and urbanization. Concern with habitat loss and fragmentation due to fire and invasive plants has mostly been focused in the western portion of the species' range. However, climate change may alter the range of invasive plants, potentially expanding this threat into other areas of the species' range.

Functional habitat loss is occurring from the expansion of native conifers, mainly due to decreased fire return intervals, livestock grazing, increases in global carbon dioxide concentrations, and climate change.

Sage-grouse populations are significantly reduced, including local extirpation, by non-renewable energy development activities, even when mitigative measures are implemented (Walker et al. 2007a, p. 2651). The persistent and increasing demand for energy resources is resulting in their continued development within sage-grouse range, and will only act to increase habitat fragmentation. Although data are limited, impacts resulting from renewable energy development are expected to have similar effects to sage-grouse populations and habitats due to their similarity in supporting infrastructure. Both non-renewable and renewable energy developments are increasing within the range of sage-grouse, and we anticipate this growth to continue given current demands for energy.

Livestock management and domestic livestock and wild horse grazing have the potential to seriously degrade sage-grouse habitat at local scales through loss of nesting cover, decreasing native vegetation, and successional stage and, therefore, vegetative resiliency, direct habitat removal through rangeland treatments, and increasing the probability of incursion of invasive plants. Fencing constructed to manage domestic livestock causes direct mortality, degradation and fragmentation of habitats, and increased predator populations. There is little direct evidence linking grazing practices to population levels of greater sage-grouse. However, testing for impacts of grazing at landscape scales important to sage-grouse is confounded by the fact that almost all sage-grouse habitat has at one time been grazed, and thus no non-grazed areas currently exist with which to compare. Known impacts from livestock grazing are heavily influenced by local grazing management, and therefore vary across the species range. The impacts of wild horses on sagebrush habitats can be locally significant, particularly in areas where herd management objectives cannot be maintained.

Restoration of sagebrush habitat is challenging, and restoring habitat function may not be possible because alteration of vegetation, nutrient cycles, topsoil, and cryptobiotic crusts have exceeded recovery thresholds. Even if possible, restoration will require decades and will be cost-prohibitive. To provide habitat for sage-grouse, restoration must include all seasonal habitats and occur on a large scale (4,047 ha (10,000 ac) or more) to provide all necessary habitat components. Restoration may never be achieved in the presence of invasive grass species.

The WAFWA identified a goal of "no net loss" of birds and habitat in their Greater Sage-grouse Comprehensive Conservation Strategy (Stiver et al. 2006, p. 1-7). Knick and Hanser (2011, p. 404) have concluded that this strategy may no longer be possible due to natural and anthropogenic threats that are degrading the remaining sagebrush habitats. They recommend focusing conservation on areas critical to range-wide persistence of this species (Knick and Hanser 2011, p. 404). Wisdom et al. (2011, p. 469) and Knick and Hanser (2011, p. 391) identified two strongholds of contiguous sagebrush habitat essential for the long-term persistence of greater sage-grouse (the southwest Wyoming Basin and the Great Basin area straddling the States of Oregon, Nevada, and Idaho). Other areas within the greater sage-grouse range had a high uncertainty for continued population persistence (Wisdom et al., 2011, p. 469) due to fragmentation from anthropogenic impacts. However, our analyses of fragmentation in the two stronghold areas showed that habitats in these areas are becoming fragmented due to wildfire, invasive species, and energy development. Therefore, we are concerned that the level of fragmentation in these areas may already be limiting sage-grouse populations and further reducing connectivity between populations. These threats have intensified over the last two decades, and as we predicted in our March 2010 status review (75 FR 13958), they are continuing to accelerate due to the positive feedback loop between fire and invasives and the persistent and increasing demand for energy resources.

Population trends and habitat fragmentation

In our March 2010 status review we examined the effects of habitat loss and fragmentation on greater sage-grouse populations and persistence using a variety of data to understand how population trends reflected the changing habitat condition (75 FR 13958-13961). Patterns of sage-grouse extirpation were identified by Aldridge et al. 2008 (entire) Johnson et al. (2011, entire), Wisdom et al. (2011, entire), Knick and Hanser (2011, entire), and others, and discussed in detail above. Fire, agricultural activities, human densities, and energy development were all identified as risks. Therefore, where these habitat factors, and others identified above, are occurring, we anticipate that sage-grouse population trends will continue to decline. This is evidenced by observed declines in sage-grouse population trends (e.g. a decrease of 30 percent from 1965 to 2007 in MZ II (Garton et al. 2011, pp. 322-323) where intensive energy development is occurring). Details of population trends by MZs and the associated activities contributing to habitat fragmentation can be found in our March 2010 status review (75 FR 13958-13961). We found no evidence in this annual review that this trend of impacts is declining, and there were no significant increases in sage-grouse populations.

Our analysis of habitat trends, and those provided in the published literature show that population extirpation and declines have, and are likely to continue to track habitat loss or environmental changes (e.g., Walker et al., 2005, Aldridge et al. 2008; Knick and Hanser 2011; Wisdom et al. 2011). Estimation of how these trends may affect future population numbers and habitat carrying capacity was conducted by Garton et al. (2011, entire), and was discussed in detail (including identification of concerns over model assumptions) in our March 2010 status review (75 FR 13959-13961). Population viability analyses can provide useful information in examining the potential future status of a species as long as the assumptions of the model, and violations thereof, are clearly identified and considered in the interpretation of the results. The projections of declining populations reported by Garton et al. (2011, entire) are consistent with what we expect given the causes of sage-grouse declines and extirpation documented in the literature (see above) and where those threats occur in the species range. We are unaware of any other prospective rangewide population viability analyses for this species, but an analysis conducted for a limited area in northeastern Montana reflected similar results (Taylor et al. 2010, in litt.).

We examined the persistence of each of these habitat threats on the landscape to help inform a determination of foreseeable future. Habitat conversion and fragmentation resulting from agricultural activities and urbanization will continue indefinitely. Human populations are increasing in the western United States and we have no data indicating this trend will be reversed. Increased fire frequency as facilitated by the expanding distribution of invasive plant species will continue indefinitely unless an effective means for controlling the invasives is found. So far, no broad scale Bromus tectorum eradication method has been developed. Therefore, given the history of invasive plants on the landscape, our continued inability to control such species, and the expansive infestation of invasive plants across the species' range currently, we anticipate they and associated fires will be on the landscape for the next 100 years or longer.

Continued exploration and development of traditional and nonconventional fossil fuel sources in the eastern portion of the greater sage-grouse range will continue to increase over the next 20 years (EIA 2009b, p. 109). Based on existing National Environmental Policy Act (NEPA) documents for major oil and gas developments, production within existing developments will continue for a minimum of 20 years, with subsequent restoration (if possible) requiring from 30 to 50 additional years. Renewable energy development is estimated to reach maximum development by 2030. However, since most renewable energy facilities are permanent landscape features, unlike oil, gas and coal, direct and functional habitat loss from the development footprint will be permanent.

Grazing (both domestic and wild horse and burro) is unlikely to be removed from sagebrush ecosystems. As of 2007, there were 7,118,989 permitted AUMs in sage-grouse habitat. Although there have been recent reductions in the number of AUMs (3.4 percent since 2005), we have no information suggesting that livestock grazing will be significantly reduced, or removed, from sage-grouse habitats.

The habitat threats identified above are contributing to significant habitat fragmentation, which is negatively affecting the greater sage-grouse. Population and carrying capacity projections suggest that some current populations will be extirpated within the foreseeable future, with many others experiencing large population declines and losses of carrying capacity. As populations lose connectivity and become smaller, they will become increasingly vulnerable to genetic, demographic, and environmental stochastic events. We have evaluated the best available scientific information on the present or threatened destruction, modification or curtailment of the greater sage-grouse's habitat or range. Based on the current and ongoing habitat issues identified here, and their synergistic effects, we have determined that this factor poses a significant threat to the species throughout its range.

B. Overutilization for commercial, recreational, scientific, or educational purposes:

A complete discussion of historical recreational hunting for the greater sage-grouse, as well as a discussion of hunting as compensatory or additive mortality for greater sage-grouse was provided in our March 2010 status review (75 FR 13962-13964). Sage-grouse have not been commercially harvested since the early 1900s. Currently, greater sage-grouse are legally sport-hunted in 10 of 11 States where they occur (Connelly et al. 2004, p. 6-3). The hunting season for sage-grouse in Washington was closed in 1988, and the species was added to the State's list of threatened species in 1998 (Stinson et al. 2004, p. 1). In Canada, sage-grouse are designated as an endangered species, and hunting is not permitted (Connelly et al. 2004, p. 6-3).

Autenrieth (1981, p. 77) suggested sage-grouse could sustain harvest rates of up to 30 percent annually. Braun (1987, p. 139) suggested a rate of 20 to 25 percent was sustainable. State wildlife agencies currently attempt to keep harvest levels below 5 to 10 percent of the population, based on recommendations from Connelly et al. (2000a, p. 976) and recently supported by Sedinger et al. (2010, p. 331). It is unclear what Connelly et al. (2000a) based the recommendation on, and it has not been experimentally tested with regard to its impacts on sage-grouse populations. Sedinger et al. (2010) modeled band return rates to examine the impacts of harvest on annual survival. However, the authors caution that greater than 10 years of data on banding and recoveries may be required to determine if hunting is a source of additive mortality in localized areas (Sedinger et al. 2010, p. 330). Therefore, more research at the local population level may be necessary to fully determine the effects of hunting on sage-grouse.

Sage-grouse hunting is regulated by State wildlife agencies. Hunting seasons are reviewed annually, and States change harvest management based on estimates for spring production and population size (e.g., Bohne 2003, pp.1-10). However, harvest affects fall populations of sage-grouse, and currently there is no reliable method for obtaining estimates of fall population size (Connelly et al. 2004, p. 9-6). Instead, lek counts conducted in the spring are used as a surrogate for fall population size. However, fall populations are already reduced from spring estimates as some natural mortality inevitably has occurred in the interim (Kokko 2001, p. 164). The discrepancy between spring and fall population size estimates plays a role in determining whether harvest will be within the recommended level of less than 5-10 percent of the fall population. For example, hen mortality in Montana increased from the typical level of 1 to 5 percent to 16 percent during July/August in a year (2003) with West Nile virus (WNv) mortality (Moynahan et al. 2006, p.1535). During the summer of 2006 and 2007 in South Dakota, mortality from WNv was estimated to be between 21 and 63 percent of the population (Kaczor 2008, p.72). Only one state, Idaho, currently delays setting hunting seasons for sage-grouse until August to allow for consideration of potential summer wildfire and disease impacts (Idaho Fish and Game Department (IDFG) 2011, in litt..).

All States with hunting seasons have changed limits and season dates to more evenly distribute hunting mortality across the entire population structure of greater sage-grouse, harvesting birds after females have left their broods (Bohne 2003, p. 5). Females and broods congregate in mesic areas late in the summer potentially making them more vulnerable to hunting (Connelly et al. 2000b, p. 230). However, despite increasingly later hunting seasons, hens continue to comprise the majority of the harvest in all years in Wyoming (Wyoming Game and Fish Department (WGFD) 2004a, p. 4; 2006, p. 7). From 1996 to 2008, on average 63 percent of adult hunting mortalities in Nevada were females (range 58 percent to 73 percent) (Nevada Division of Wildlife (NDOW) 2009, unpublished data). In 2008 in Oregon, adult females accounted for 70 percent of the adults harvested (Oregon Department of Fish and Wildlife (ODFW) 2009). These results could indicate that females are more susceptible to hunting mortality, or it could be a reflection of a female skewed sex ratio in adult birds. Male sage-grouse typically have lower survival rates than females, and the varying degrees of female skewed sex ratios recorded for sage-grouse are thought to be as a result of this differential survival (Swenson 1986, p. 16; Colorado Greater Sage-grouse Steering Committee. 2008, p. 54). The potential for negative effects on populations by harvesting reproductive females has long been recognized by upland game managers (e.g., hunting of female ring-necked pheasants, (Phasianus colchicus), is prohibited in most States).

Harvest management levels that are based on the concept of compensatory mortality assume that overwinter mortality is high, which is not true for sage-grouse (winter mortality rates are approximately 2 percent, Connelly et al. 2000b, p. 229). Additionally, due to WNv, sage-grouse population dynamics may be increasingly affected by mortality that is density independent (i.e., mortality that is independent of population size). Further, there is growing concern regarding wide-spread habitat degradation and fragmentation from various sources, such as development, fire, and the spread of noxious weeds, resulting in density independent mortality which increases the probability that harvest mortality will be additive. However, analyses of long-term harvest data from North Park, CO and NW Nevada suggest that hunting was not additive (Sedinger et al. 2010, p. 330).

State management agencies have become increasingly responsive to these concerns. All of the States where hunting greater sage-grouse is legal, except Montana, now manage harvests on a regional scale rather than applying State-wide limits. Bag limits and season lengths are relatively conservative compared to prior decades (Connelly 2005, p. 9; Gardner 2008, pers. comm.; Christiansen in litt 2010, pp. 6-10). Emergency closures have been used for some declining populations. For example, North Dakota closed the 2008 and 2009 hunting seasons following record low lek attendance likely due to WNv (Robinson 2009, pers. comm.). That closure has been extended through 2011 (North Dakota Game and Fish (NDFG) 2011, pers. comm.). Hunting on the Duck Valley Indian Reservation (Idaho/Nevada) has been closed since 2006 due to WNv (Dick 2009, pers. comm.; Gossett 2008, pers. comm.). The season will remain closed pending analyses of population data (Perugini 2011, pers. comm.). Hunting in a portion Owyhee County, Idaho was closed in 2006 and again in 2008 and 2009 as a result of WNv (Dick 2008, pers. comm.; IDFG 2009).

In 2010, Idaho closed the season in the area around the Murphy Complex Fire due to declines in lek attendance, and reduced the harvest length and bag limit in two additional hunt areas for similar reasons (IDGF 2011, in litt.). The reduction in harvest length and bag limit is consistent with hunting guidance used annually by the State to evaluate harvest levels. Colorado and Wyoming each had similar reductions for areas in their states ((CDOW) 2011, in litt.; WGFD 2011, in litt.). The continuation of those harvest reductions will be re-evaluated for 2011, after data from 2011 spring lek counts are analyzed (CDOW 2011, in litt.; WGFD 2011, in litt.). South Dakota has not made changes to its hunting season, but will make recommendations regarding the 2011 season after spring lek counts are completed (South Dakota Department of Game, Fish and Parks (SDGFP) 2011, in litt.).

All States that allow bow and gun hunting of sage-grouse also allow falconers to hunt sage-grouse. Falconry seasons are typically longer (60 to 214 days), and in some cases have larger bag limits than bow/gun seasons. However, due to the low numbers of falconers and their dispersed activities, the resulting harvest is thought to be negligible (Apa 2008, pers. comm.; Northrup 2008, pers. comm.; Hemker 2008, pers. comm.; Olsen 2008, pers. comm.; Kanta 2008, pers. comm.; Christiansen in litt. 2010, p. 10). Wyoming is one of the few States that collects falconry harvest data and reported a take of 180 sage-grouse by falconers in the 2006-2007 season (Christiansen in litt. 2010, p. 10). In Oregon, the take is probably less than five birds per year (Budeau 2008, pers. comm.). In Idaho the 2005 estimated Statewide falconry harvest was 77 birds, and that number has likely remained relatively constant (Hemker 2008, pers. comm.). We are not aware of any studies that have examined falconry take of greater sage-grouse in relation to population trends, but the amount of greater sage-grouse mortality associated with falcon sport hunting appears to be negligible.

We previously surveyed the State fish and wildlife agencies within the range of greater sage-grouse to determine what information they had on illegal harvest (poaching) of the species. Nevada and Utah indicated they were aware of citations being issued for sage-grouse poaching, but that it was rare (Espinosa 2008, pers. comm.; Olsen 2008, pers. comm.). Sage-grouse wings are infrequently discovered in wing-barrel collection sites during forest grouse hunts in Washington, but such take is considered a result of hunter misidentification rather than deliberate poaching (Schroeder 2008, pers. comm.). None of the remaining States had any quantitative data on the level of poaching. No new information regarding the level of poaching on greater sage-grouse was presented in response to our 2011 data request. Therefore, we continue to conclude that poaching appears to only occur at low levels. We are not aware of any studies or other data that demonstrate that poaching has contributed to sage-grouse population declines.

Greater sage-grouse are subject to a variety of non-consumptive recreational uses such as bird watching or tour groups visiting leks, general wildlife viewing, and photography. Daily human disturbances on sage-grouse leks could cause a reduction in mating and some reduction in total production (Call and Maser 1985, p. 19). Overall, a relatively small number of leks in each State receive regular viewing use by humans during the strutting season and most States report no known impacts from this use (Apa 2008, pers. comm.; Christiansen 2008, pers. comm.; Gardner 2008, pers. comm.; Northrup 2008, pers. comm.). Only Colorado has collected data regarding the effects of non-consumptive use. Their analyses suggest that controlled lek visitation has not impacted greater sage-grouse (Apa 2008, pers. comm.). However, Oregon reported anecdotal evidence of negative impacts of unregulated viewing to individual leks near urban areas that are subject to frequent disturbance from visitors (Hagen 2008, pers. comm.).

To reduce any potential impact of lek viewing on sage-grouse, several States have implemented measures to protect most leks while allowing recreational viewing to continue. The WGFD provides the public with directions to 16 leks and guidelines to minimize viewing disturbance. Leks included in the brochure are close to roads and already subject to some level of disturbance (Christiansen 2008, pers. comm.); presumably, focusing attention on these areas reduces pressure on relatively undisturbed leks. Colorado and Montana have some sites with viewing trailers for the public for the same reasons (Apa 2008, pers. comm.; Northrup 2008, pers. comm.). We were not able to locate any studies documenting how lek viewing, or other forms of non-consumptive recreational uses, of sage-grouse are related to sage-grouse population trends. Given the relatively small number of leks visited, we have no reason to believe that this type of recreational activity is having a negative impact on local populations or contributing to declining population trends.

Some Native American tribes harvest greater sage-grouse as part of their religious or ceremonial practices as well as for subsistence. Hunting by Native American occurs on the Wind River Indian Reservation (Wyoming), with about 20 males per year taken off of leks in the spring plus an average fall harvest of approximately 40 birds (Hnilicka 2008, pers. comm.). The Shoshone-Bannock Tribe (Idaho) occasionally takes small numbers of birds in the spring, but no harvest figures were reported for 2007 and 2008 (Christopherson 2008, pers. comm.). The Shoshone-Paiute Tribe of the Duck Valley Indian Reservation (Idaho and Nevada) suspended hunting in 2006 to 2009 due to significant population declines resulting from a WNv outbreak in the area (Dick 2009, pers. comm.; Gossett 2008, pers. comm.). Prior to 2006, the sage-grouse hunting season on the Duck Valley Indian Reservation ran from July 1 to November 30 with no bag or possession limits. Preliminary estimates indicate that the harvest may have been as high as 25 percent of the population (Gossett 2008, pers. comm.). Despite the hunting ban, populations have not recovered on the reservation (Dick 2009, pers. comm.; Gossett 2008, pers. comm.). No harvest by Native Americans for subsistence or religious and ceremonial purposes occurs in South Dakota, North Dakota, Colorado, Washington, or Oregon (Apa 2008, pers. comm.; Hagen 2008, pers. comm.; Kanta 2008, pers. comm.; Robinson 2008, pers. comm.; Schroeder 2008, pers. comm.).

Greater sage-grouse are the subject of many scientific research studies. We are aware of 51 studies ongoing or completed during 2005 and 2008. Information received in 2011 suggests that research activities continue in at least 5 states (OR, CO, WY, ID, NV); other states did not provide any information regarding research. All of the states where sage-grouse currently occur reported some type of field studies that included the capture, handling, and subsequent banding, or banding and radio-tagging of sage-grouse. In 2005, the overall mortality rate due to the capture, handling, and/or radio-tagging process was calculated at approximately 2.7 percent of the birds captured (68 mortalities of 2,491 captured). A survey of State agencies, BLM, consulting companies, and graduate students involved in sage-grouse research indicates that there has been little change in direct handling mortality since then. Only Colorado reported that mortality had occurred amongst their marked birds (CDOW 2011, pers. comm.), but it was unclear as to how much of that mortality, if any, could be attributed to the research activities. We are not aware of any studies that document that this level of taking has affected any sage-grouse population trends.

Greater sage-grouse have been translocated in several States and the Province of British Columbia (Reese and Connelly 1997, p. 235). Reese and Connelly (1997, pp. 235-238) documented the translocation of over 7,200 birds between 1933 and 1990. Only 5 percent of the translocation efforts documented by Reese and Connelly (1997, p. 240) were considered to be successful in producing sustained, resident populations at the translocation sites. From 2003 to 2005, 137 adult female sage-grouse were translocated to Strawberry Valley, Utah and had a 60 percent annual survival rate (Baxter et al. 2008, p. 182). Since 2004, Oregon and Nevada have supplied the State of Washington with close to 100 greater sage-grouse to increase the genetic diversity of the geographically isolated Columbia Basin populations and to reestablish a historical population. One bird has died during transit and, as expected, natural mortality for translocated birds has been higher than resident populations (Schroeder 2008, pers. comm.). Oregon is contributing up to 80 birds for translocation efforts in California and Washington in 2011 (ODFW 2011, in litt.). Given the low numbers of birds that have been used for translocation spread over many decades, it is unlikely that the removals from source populations have contributed to greater sage-grouse declines, while the limited success of translocations also has likely had nominal impact on rangewide population trends. We did not find any information regarding the direct use of greater sage-grouse for educational purposes.

We have no information that suggests any significant changes have, or will occur in the use of sage-grouse for recreational, religious, or scientific purposes regarding recreational hunting based on our 2011 survey. Although we have no evidence suggesting that gun and bow sport hunting has been a primary cause of range-wide declines of the greater sage-grouse in the recent past, negative impacts on local populations have been demonstrated and there remains a large amount of uncertainty regarding harvest impacts because of a lack of experimental evidence and conflicting studies. There is evidence that the sustainability of harvest levels depends to a large extent upon the quality of habitat and the health of the population. However, we do not believe data indicate that overuse of sage-grouse as a singular factor has caused rangewide population declines.

C. Disease or predation:

<u>Disease</u>

Greater sage-grouse are hosts for a variety parasites and diseases, including macroparasitic arthropods, helminths and microparasites (protozoa, bacteria, viruses and fungi) (Thorne et al. 1982, p. 338; Connelly et al. 2004, pp. 10-4 to 10-7; Christiansen and Tate, 2011, p. 114). However, there have been few systematic surveys for parasites or infectious diseases of greater sage-grouse; therefore, whether they have a role in population declines is unknown (Connelly et al. 2004, p. 10-3; Christiansen and Tate, 2011, p. 114). Early studies have suggested that sage-grouse populations are adversely affected by parasitic infections (Batterson and Morse 1948, p. 22). Parasites also have been implicated in sage-grouse mate selection, with potential subsequent effects on the genetic diversity of this species (Boyce 1990, p. 263; Deibert 1995, p. 38). However, Connelly et al. (2004, p. 10-6) note that, while these relationships may be important to the long-term ecology of greater sage-grouse, they have not been shown to be significant to its immediate population status. Connelly et al. (2004, p. 10-3) have suggested that diseases and parasites may limit isolated sage-grouse populations, but that the effects of emerging diseases require additional study (see also Christiansen and Tate, 2011, p. 126).

A complete review of parasites and diseases of the greater sage-grouse and associated research on their impacts can be found in our March 2010 status review (75 FR 13966 – 13967). Only a few of these pathogens has had documented population-level effects on the greater sage-grouse, (coccidiosis and ioxdid ticks) but these have been geographically isolated incidents associated with atypical environmental conditions (Parker et al. 1932, p. 480; Scott 1940, p. 45; Honess and Post 1968, p. 20; Connelly et al. 2004, p. 10-4; Christiansen and Tate, 2011, pp. 119, 120). One of the few diseases that has had population level impacts to the greater sage-grouse across its entire range is the recently introduced West Nile virus (WNv).

West Nile virus was introduced into the northeastern United States in 1999 and has subsequently spread across North America (Marra et al. 2004, p.394). This virus is thought to have caused millions of wild bird deaths since its introduction (Walker and Naugle 2011, p. 128), but most WNv mortality goes unnoticed or unreported (Ward et al. 2006, p. 101). The virus persists largely within a mosquito-bird-mosquito infection cycle (McLean 2006, p. 45). However, direct bird-to-bird transmission of the virus has been documented in several species (McLean 2006, pp. 54, 59) including the greater sage-grouse (Walker and Naugle 2011, p. 132; Cornish 2009a, pers. comm.). The frequency of direct transmission has not been determined (McLean 2006, p. 54).

Impacts of WNv on the bird host varies by species with some species being relatively unaffected (e.g., common grackles (Quiscalus quiscula)) and others experiencing mortality rates of up to 68 percent (e.g., American crow (Corvus brachyrhynchos)) (Walker and Naugle 2011, p. 129, and references therein). Greater sage-grouse are considered to have a high susceptibility to WNv, with resultant high levels of mortality (Clark et al. 2006, p. 19; McLean 2006, p. 54).

In sagebrush habitats, WNv transmission is primarily regulated by environmental factors, including temperature, precipitation and anthropogenic water sources, such as stock ponds and coal-bed methane ponds that support the mosquito vectors (Reisen et al. 2006, p. 309; Walker and Naugle 2011, p. 132). Cold ambient temperatures preclude mosquito activity and virus amplification, so transmission to and among sage-grouse is limited to the summer (mid-May to mid-September) (Naugle et al. 2005, p. 620; Zou et al. 2007, p. 4), with a peak in July and August (Walker and Naugle 2011, p. 131). Reduced and delayed WNv transmission in sage-grouse has occurred in years with lower summer temperatures (Naugle et al. 2005, p. 621; Walker et al. 2007b, p. 694). In non-sagebrush ecosystems, high temperatures associated with drought conditions increase WNv transmission by allowing for more rapid larval mosquito development and shorter virus incubation periods (Shaman et al. 2005, p.134; Walker and Naugle 2011, p. 131). Greater sage-grouse congregate in mesic habitats in the mid-late summer (Connelly et al. 2000, p. 971) thereby increasing the risk of exposure to mosquitoes. If WNv outbreaks coincide with drought conditions that aggregate birds in habitat near water sources, the risk of exposure to WNv will be elevated (Walker and Naugle 2011, p. 131).

Greater sage-grouse inhabiting higher elevation sites in summer are likely less vulnerable to contracting WNv than birds at lower elevation as ambient temperatures are typically cooler (Walker and Naugle 2011, p. 131). Greater sage-grouse populations in northwestern Colorado and western Wyoming are examples of high elevation populations with lower risk for impacts from WNv (Walker and Naugle 2011, p. 140). Also, due to summer temperatures generally being lower in more northerly areas, sage-grouse populations that are in geographically more northern populations may be less susceptible than those at similar elevations farther south (Naugle et al. 2005, cited in Walker and Naugle 2011, p. 131). Climate change could result in increased temperatures and thus potentially exacerbate the prevalence of WNv, and thereby impacts on greater sage-grouse, but this risk also depends on complex interactions with other environmental factors including precipitation and distribution of suitable water (Walker and Naugle 2011, p. 132)

The primary vector of WNv in sagebrush ecosystems is Culex tarsalis, a species of mosquito (Naugle et al. 2004, p. 711; Naugle et al. 2005, p. 617; Walker and Naugle 2011, p. 129). Individual mosquitoes may disperse as much as 18 km (11.2 mi) (Miller 2009, pers. comm.; Walker and Naugle 2011, p.129). This mosquito species is capable of overwinter survival and, therefore, can emerge as infected adults the following spring (Walker and Naugle 2011, p. 130 and references therein), thereby decreasing the time for disease cycling (Miller 2009, pers. comm.). This ability may increase the occurrence of this virus at higher elevation populations or where ambient temperatures would otherwise be insufficient to sustain the entire mosquito-virus cycle.

In greater sage-grouse, mortality from WNv occurs at a time of year when survival is otherwise typically high for adult females (Schroeder et al. 1999, p.14; Aldridge and Brigham 2003, p. 30), thus potentially making these deaths additive and reducing average annual survival (Naugle et al. 2005, p. 621). WNv has been identified as a source of additive mortality in American white pelicans (Pelecanus erythrorhynchos) in the northern plains breeding colonies (Montana, North Dakota and South Dakota), and its continued impact has the potential to severely impact the entire pelican population (Sovada et al. 2008, p. 1030).

WNv was first detected in 2002 as a cause of greater sage-grouse mortalities in Wyoming (Walker and Naugle 2011, p. 133). Data from four studies in the eastern half of the sage-grouse range (Alberta, Montana, and Wyoming; MZ I) showed survival in these populations declined 25 percent in July and August of 2003 as a result of the WNv infection (Naugle et al. 2004, p. 711). Populations of sage-grouse that were not affected by WNv showed no similar decline. Additionally, individual sage-grouse in exposed populations were 3.4 times more likely to die during July and August, the peak of WNv occurrence, than birds in non-exposed populations (Connelly et al. 2004, p. 10-9; Naugle et al. 2004, p. 711). Subsequent declines in both male and female lek attendance in infected areas in 2004 compared with years before WNv suggest outbreaks could contribute to local population extirpation (Walker et al. 2004, p. 4). One outbreak near Spotted Horse, Wyoming in 2003 was associated with the subsequent extirpation of the local breeding population, with five leks affected by the disease becoming inactive within 2 years (Walker and Naugle 2011, p. 134). Lek surveys in northeastern Wyoming in 2004 indicated that regional sage-grouse populations did not decline, suggesting that the initial effects of WNv were localized (WGFD, unpublished data, 2004b).

Eight sage-grouse deaths resulting from WNv were identified in 2004: four from the Powder River Basin area of northeastern Wyoming and southeastern Montana, one from the northwestern Colorado, near the town of Yampa, and three in California (Naugle et al. 2005, p. 618). Fewer other susceptible hosts succumbed to the disease in 2004, suggesting that below average precipitation and summer temperatures may have limited mosquito production and disease transmission rates (Walker and Naugle 2011, p. 155). However, survival rates in greater sage-grouse in July and September of that year were consistently lower in areas with confirmed WNv mortalities than those without (avg. 0.86 and 0.96, respectively; Walker and Naugle 2011, p. 135). There were no comprehensive efforts to track sage-grouse mortalities outside of these areas, so the actual distribution and extent of WNv in sage-grouse in 2004 is unknown (70 FR 2270).

Mortality rates from WNv in northeastern Wyoming and southeastern Montana (MZ I) were between 2.4 (estimated minimum) and 28.9 percent (estimated maximum) in 2005 (Walker et al. 2007b, p. 693). Sage-grouse mortalities also were reported in California, Nevada, Utah, and Alberta, but no mortality rates were calculated (Walker and Naugle 2011, p. 135). Mortality rates in 2006 in northeastern Wyoming ranged from 5 to 15 percent of radio-marked females (Walker and Naugle 2011, p. 135). Mortality rates in South Dakota among radio-marked juvenile sage-grouse ranged between 6.5 and 71 percent in the same year (Kaczor 2008, p. 63). Large sage-grouse mortality events, likely the result of WNv, were reported in the Jordan Valley and near Burns, Oregon (over 60 birds), and in several areas of Idaho and along the Idaho-Nevada border (over 55 birds) (Walker and Naugle 2011, p. 135). While most of the carcasses had decomposed and, therefore, were not testable, results for the few that were tested showed that they died from WNv. Mortality rates in these areas were not calculated. However, the hunting season in Owyhee County, Idaho, was closed that year due to the large number of birds that succumbed to the disease (USGS 2006, p. 1; Walker and Naugle 2011, p. 135).

In 2007, a WNv outbreak in South Dakota contributed to a 44-percent mortality rate among 80 marked females (Walker and Naugle 2011, p. 135). Juvenile mortality rates in 2007 in the same area ranged from 20.8 to 62.5 percent (Kaczor 2008, p. 63), reducing recruitment the subsequent spring by 2 to 4 percent (Kaczor 2008, p. 65). Twenty-six percent of radio-marked females in northeastern Montana died during a 2-week period immediately following the first detection of WNv in mosquito pools. Two of those females were confirmed dead from WNv (Walker and Naugle 2011, p. 135). In the Powder River Basin, WNv-related mortality among 85 marked females was between 8 and 21 percent (Walker and Naugle 2011, p. 135). A 52-percent decline in the number of males attending leks in North Dakota between 2007 and 2008 also were associated with WNv mortality in 2007 that prompted the State wildlife agency to close the hunting season in 2008 (North Dakota Game and Fish 2008, entire) and 2009 (Robinson 2009, pers. comm.). The Duck Valley Indian Reservation along the border of Nevada and Idaho closed their hunting season in 2006 due to population declines resulting from WNv (Gossett 2008, pers. comm.). WNv is still present in that area, with continued population declines (50.3 percent of average males per lek from 2005 to 2008) (Dick 2008, p. 2), and the hunting season remains closed. The hunting season was closed in most of the adjacent Owyhee County, Idaho for the same reason in both 2008 and 2009 (Dick 2008, pers. comm.; IDFG 2009).

Only Wyoming reported WNv mortalities in sage-grouse in 2008 (Cornish 2009b, pers. comm.). However, with the exceptions of Colorado, California, and Idaho, research on sage-grouse in other States is limited, minimizing the ability to identify mortalities from the disease, or recover infected birds before tissue deterioration precludes testing. Three sage-grouse deaths were confirmed in 2009 in Wyoming (Cornish 2009b, pers. comm.), along with two in Idaho (Moser 2009, pers. comm.).

Greater sage-grouse deaths resulting from WNv have been detected in 10 States and 1 Canadian province. To date, no sage-grouse mortality from WNv has been identified in either Washington State or Saskatchewan. However, it is likely that sage-grouse have been infected in Saskatchewan based on known patterns of sage-grouse in infected areas of Montana (Walker and Naugle 2011, p. 133). Also, WNv has been detected in other species within the range of greater sage-grouse in Washington (USGS 2009). No sage-grouse deaths due to WNv were identified anywhere throughout the species' range in 2010 (CDOW 2011, in litt.; IDFG 2011, in litt.; Gardner 2011, pers. comm.; MTFWP 2011, in litt.; NDOW 2011, in litt. ; NDGF 2011, in litt.; ODFW 2011, in litt.; SDFWP 2011, in litt.; UDWR 2011, in litt.; WGFD 2011, in litt.). This is likely a result of weather conditions limiting the mosquito vector on the landscape rather than the eradication of the disease on the landscape.

In 2005, we reported that there was little evidence that greater sage-grouse can survive a WNv infection (70 FR 2270). This conclusion was based on the lack of sage-grouse found to have antibodies to the virus and from laboratory studies in which all sage-grouse exposed to the virus, at varying doses, died within 8 days or less (70 FR 2270; Clark et al. 2006, p. 17). These data suggested that sage-grouse do not develop a resistance to the disease, and death is certain once an individual is exposed (Clark et al. 2006, p. 18). However, 6 of 58 females (10.3 percent) birds captured in the spring of 2005 in northeastern Wyoming and southeastern Montana were seropositive for neutralizing antibodies, which suggests they were exposed to the virus the previous fall and survived an infection. Additional, but significantly fewer (2 of 109, or 1.8 percent) seropositive females were found in the spring of 2006 (Walker et al. 2007b, p. 693). Of approximately 1,400 serum tests on sage-grouse from South Dakota, Montana, Wyoming and Alberta, only 8 tested positive for exposure to WNv (Cornish 2009c pers. comm.), suggesting that survival is extremely low. Seropositive birds have not been reported from other parts of the species' range (Walker and Naugle 2011, p.136).

The duration of immunity conferred by surviving an infection is unknown (Walker and Naugle 2011, p. 136). Although no WNv mortalities were reported in 2010, we have no data to determine if that was the result of a potential immune response in sage-grouse, or simply due to unsuitable weather conditions for completion of the virus-mosquito vector cycle. Weather conditions in northeastern Wyoming, where WNv has been documented every year since 2002, did not support the mosquito virus cycle in 2010 (Big Horn Environmental in litt. 2011, p. 6).

Several variants of WNv have emerged since the original identification of the disease in the United States in 1999. One variant, termed NY99, has proven to be more virulent than the original virus strain of WNv, increasing the frequency of disease cycling (Miller 2009, pers. comm.). This constant evolution of the virus could limit resistance development in the greater sage-grouse.

Walker and Naugle (2011, pp. 136-139) modeled variability in greater sage-grouse population growth for the next 20 years based on current conditions under three WNv impact scenarios. These scenarios included: (1) no mortalities from WNv; (2) WNv- related mortality based on rates of observed infection and mortality rate data from 2003 to 2007; and (3) WNv-related mortality with increasing resistance to the disease over time. The addition of WNv-related mortality (scenario 2) resulted in a reduction of population growth. The proportion of resistant individuals in the modeled population increased marginally over the 20-year projection periods, from 4 to 15 percent, under the increasing resistance scenario (scenario 3). While this increase in the proportion of resistant individuals did reduce the projected WNv rates, the authors caution that the presence of neutralizing antibodies in the live birds does not always indicate that these birds are actually resistant to infection and disease (Walker and Naugle 2011, p. 140).

Additional models predicting the prevalence of WNv suggest that new sources of anthropogenic surface waters (e.g., coal-bed methane discharge ponds), increasing ambient temperatures, and a mosquito parasite that reduces the length of time the virus is present in the vector before the mosquito can spread the virus all suggest the impacts of this disease are likely to increase (Miller 2008, pers. comm.). However, the extent to which this will occur, and where, is unclear and difficult to predict because several conditions that support the WNv cycle must coincide for an outbreak to occur.

It is unclear whether sage-grouse have sub-lethal or residual effects resulting from a WNv infection, such as reduced productivity or overwinter survival (Walker et al. 2007b, p. 694). Other bird species infected with WNv have been documented to suffer from chronic symptoms, including reduced mobility, weakness, disorientation, and lack of vigilance (Marra et al. 2004, p. 397; Nemeth et al. 2006, p. 253), all of which may affect survival, reproduction, or both (Walker and Naugle in press, p. 20). Reduced productivity in American white pelicans has been attributed to WNv (Sovada et al. 2008, p.1030).

Human-created water sources in sage-grouse habitat known to support breeding mosquitoes that transmit WNv include overflowing stock tanks, stock ponds, irrigated agricultural fields and coal-bed natural gas discharge ponds (Zou et al. 2006, p. 1035). For example, from 1999 through 2004, potential mosquito habitats in the Powder River Basin of Wyoming and Montana increased 75 percent (619 ha to 1084.5 ha; 1259 ac to 2680) primarily due to the increase of small coal-bed natural gas water discharge ponds (Zou et al. 2006, p. 1034). Additionally, water developments installed in arid sagebrush landscapes to benefit wildlife continue to be common. Several scientists have expressed concern regarding the potential for exacerbating WNv persistence and spread due to the proliferation of surface water features (e.g., Friend et al., 2001, p. 298; Zou et al. 2006, p.1040; Walker et al. 2007b, p. 695; Walker and Naugle 2011, p. 141). Walker et al. (2007a, p. 694) concluded that impacts from WNv will depend less on resistance to the disease than on temperatures and changes in vector distribution. Zou et al. (2006, p. 1040) cautioned that the continuing development of coal-bed natural gas facilities in Wyoming and Montana contributes to maintaining, and possibly increasing WNv on that landscape through the maintenance and proliferation of surface water. However, growing industry awareness of WNv concerns has prompted the implementation of water management plans to minimize mosquito presence through pond design and the incorporation of mosquito larvicide in created surface waters (Big Horn Environmental in litt. 2011, p. 3).

The long-term response of different sage-grouse populations to WNv infections is expected to vary markedly depending on factors that influence exposure and susceptibility, such as temperature, land uses, and sage-grouse population size (Walker and Naugle 2011, p. 140). Small, isolated, or genetically limited populations are at higher risk as an infection may reduce population size below a threshold where recovery is no longer possible, as observed with the extirpated population near Spotted Horse, Wyoming (Walker and Naugle 2011, p. 140). Larger populations may be able to absorb impacts resulting from WNv as long as the quality and extent of available habitat supports positive population growth (Walker and Naugle 2011, p. 140). However, impacts from this disease may act synergistically with other stressors resulting in reduction of population size, bird distribution, or persistence (Walker et al. 2007a, p. 2652). WNv persists on the landscape after it first occurs as an epizootic, suggesting this virus will remain a long-term issue in affected areas (McLean 2006, p. 50).

A discussion regarding proactive measures to reduce the impact of WNv on greater sage-grouse can be found in our March 2010 status review (75 FR 13969-13970). One such measure is to control mosquitoes in surface water, but this method will only be effective if such methods are consistently and appropriately implemented (Walker and Naugle 2011, p. 140). Many coal-bed natural gas companies in northeastern Wyoming (MZ I) have identified use of mosquito larvicides in their management plans (Big Horn Environmental Consultants in litt., 2009, p. 3). However, we could find no information on the actual use of the larvicides or their effectiveness. One experimental treatment in the area did report that mosquito larvae numbers were lower in ponds treated with larvicides than in those that were not (Big Horn Environmental Consultants in litt., 2009, pp. 5-7; Big Horn Environmental Consultants in litt, 2011, p. 4) but statistical analyses were not conducted. While none of the sage-grouse mortalities in the treated areas were due to WNv (Big Horn Environmental Consultants 2009, p.3), the study design precluded actual cause and effect analyses; therefore, the results are inconclusive. The benefits of mosquito control in potentially reducing the incidence of WNv in sage-grouse (Big Horn Environmental Consultants in litt., 2011, p.2) need to be considered in light of the potential detrimental or cascading ecological effects of widespread spraying (Marra et al. 2004, p. 401). Costs of controlling mosquitoes may also be cost prohibitive simply due to the extent and abundance of surface water (Big Horn Environmental Consultants in litt., 2011, p.2).

Small populations may be at high risk of extirpation simply due to their low population numbers and the additive mortality WNv causes (Christiansen and Tate, 2011, p. 126). Larger populations may be better able to sustain losses from WNv (Walker and Naugle 2011, p. 140) simply due to their size. However, as other impacts to grouse and their habitats described under Factor A affect these areas, these secure areas or sage-grouse “refugia” also may be at risk (e.g., southwestern Wyoming, south-central Oregon). Existing and developing models suggest that the occurrence of WNv is likely to increase throughout the range of the species into the future.

Although greater sage-grouse are host to a wide variety of diseases and parasites, few have resulted in population effects, with the exception of WNv. Sub-lethal effects of these disease and parasitic infections on sage-grouse have never been studied, and, therefore, are unknown. WNv is distributed throughout the species’ range, and affected sage-grouse populations experience high mortality rates with resultant, often large reductions in local population numbers. Infections in northeastern Wyoming, southeastern Montana, and the Dakotas seem to be the most persistent, with mortalities recorded in that area every year since WNv was first detected in sage-grouse. However, no infections were recorded across the species’ range in 2010. Limited information suggests that sage-grouse may be able to survive an infection; however, because of the apparent low level of immunity and continuing changes within the virus, widespread resistance is unlikely.

There are few regular monitoring efforts for WNv in greater sage-grouse; most detection is the result of research with radio-marked birds, or the incidental discovery of large mortalities. In Saskatchewan, where the greater sage-grouse is listed as an endangered species, no monitoring for WNv occurs (McAdams 2009, pers. comm.). Without a comprehensive monitoring program, the extent and effects of this disease on greater sage-grouse rangewide cannot be determined. However, it is clear that WNv is persistent throughout the range of the greater sage-grouse, and is likely a locally significant mortality factor. The lack of detection in 2010 is likely weather-related, and not a reflection of immunity development or eradication of the virus. We anticipate that WNv will persist within sage-grouse habitats indefinitely, and will remain a threat to greater sage-grouse until they develop a resistance to the virus.

The most significant environmental factors affecting the persistence of WNv within the range of sage-grouse are ambient temperatures and surface water abundance and development. The continued development of anthropogenic sources of warm standing water throughout the range of the species will likely increase the prevalence of the virus in sage-grouse, as predicted by Walker and Naugle (2011, pp. 137-139; see discussion above). Areas with intensive energy development may be at a particularly high risk for continued WNv mortalities due to the development of surface water features, and the continued loss and fragmentation of habitats (see discussion of energy development above). Impacts may be ameliorated if energy companies continue to be aggressive in mosquito control. Resultant changes in temperature as a result of climate change also may exacerbate the prevalence of WNv and thereby impacts on greater sage-grouse unless they develop resistance to the virus.

WNv is a significant mortality factor for greater sage-grouse when an outbreak occurs, given the bird's lack of resistance and the continued proliferation of water sources throughout the range of the species. However, a complex set of environmental and biotic conditions that support the WNv cycle must coincide for an outbreak to occur. Currently the annual patchy distribution of the disease, both spatial and temporal, is keeping the impacts at a minimum. Therefore, we do not believe that WNv, or other identified diseases of the greater sage-grouse, are currently a threat to the long-term persistence of the species.

<u>Predation</u>

Predation is the most commonly identified cause of direct mortality for sage-grouse during all life stages (Schroeder et al. 1999, p. 9; Connelly et al. 2000b, p. 228; Connelly et al. 2011a, p.65). However, sage-grouse have co-evolved with a variety of predators, and their cryptic plumage and behavioral adaptations have allowed them to persist despite this mortality factor (Schroeder et al. 1999, p. 10; Coates 2007 p. 69; Coates and Delehanty 2008, p. 635; Hagen 2011, p. 96). Until recently, there has been little published information that indicates predation is a limiting factor for the greater sage-grouse (Connelly et al. 2004, p. 10-1), particularly where habitat quality has not been compromised (Hagen 2011, p. 96). Although many predators will consume sage-grouse, none specialize on the species (Hagen 2011, p. 97). However, generalist predators have the greatest effect on ground nesting birds because predator numbers are independent of prey density (Coates 2007, p. 4; Coates and Delehanty 2010, p. 240).

Major predators of adult sage-grouse include many species of diurnal raptors (especially the golden eagle), red foxes, and bobcats (Lynx rufus) (Hartzler 1974, pp. 532-536; Schroeder et al. 1999, pp. 10-11; Schroeder and Baydack 2001, p. 25; Rowland and Wisdom 2002, p. 14; Hagen 2011, p. 97). Juvenile sage-grouse also are killed by many raptors as well as common ravens, badgers (Taxidea taxus), red foxes, coyotes and weasels (Mustela spp.) (Braun 1995, entire; Schroeder et al. 1999, p. 10). Nest predators include badgers, weasels, coyotes, common ravens, American crows and magpies (Pica spp.). Elk (Holloran and Anderson 2003, p.309) and domestic cows (Bovus spp.) (Coates et al. 2008, pp. 425-426), have been observed to eat sage-grouse eggs. Ground squirrels (Spermophilus spp.) also have been identified as nest predators (Patterson 1952, p. 107; Schroeder et al. 1999, p. 10; Schroder and Baydack 2001, p. 25), but recent data show that they are physically incapable of puncturing eggs (Holloran and Anderson 2003, p 309; Coates et al. 2008, p 426; Hagen 2011, p. 97). Several other small mammals visited sage-grouse nests monitored by videos in Nevada, but none resulted in predation events (Coates et al. 2008, p. 425). Great Basin gopher snakes (Pituophis catenifer deserticola) were observed at nests, but no predation occurred.

Adult male greater sage-grouse are very susceptible to predation while on the lek (Schroeder et al. 1999, p. 10; Schroeder and Baydack 2000, p. 25; Hagen 2011, p. 97), presumably because they are very conspicuous while performing their mating displays. Because leks are attended daily by numerous birds, predators also may be attracted to these areas during the breeding season (Braun 1995). Connelly et al. (2000b, p.228) found that among 40 radio-collared males, 83 percent of the mortality was due to predation and 42 percent of those mortalities occurred during the lekking season (March through June). Adult female greater sage-grouse are susceptible to predators while on the nest but mortality rates are low (Hagen 2011, p. 97). Hens will abandon their nest when disturbed by predators (Patterson 1952, p. 110), likely reducing this mortality (Hagen 2011, p. 97). Hens also only leave the nest to forage during low-light conditions (just before sunrise and just after sunset) to avoid cueing diurnal predators, such as ravens, to the location of the nest (Coates and Delehanty

2008, p. 635). Connelly et al. (2000b, p. 228) found that among 77 radio-collared adult hens that died, 52 percent of the mortality was due to predation, and 52 percent of those mortalities occurred between March and August, which includes the nesting and brood-rearing periods. Because sage-grouse are highly polygynous with only a few males breeding per year, sage-grouse populations are likely more sensitive to predation upon females. Predation of adult sage-grouse is low outside the lekking, nesting and brood-rearing season (Connelly et al. 2000b, p. 230; Naugle et al. 2004, p. 711; Moynahan et al. 2006, p. 1536; Hagen 2011, p. 97).

Estimates of predation rates on juveniles are limited due to the difficulties in studying this age class (Aldridge and Boyce 2007, p. 509; Hagen 2011, p.97). Chick mortality from predation ranged from 27 percent to 51 percent in 2002 and 10 percent to 43 percent in 2003 on three study sites in Oregon (Gregg et al. 2003a, p. 15; 2003b, p. 17). Mortality due to predation during the first few weeks after hatching was estimated to be 82 percent (Gregg et al. 2007, p. 648). Based on partial estimates from three studies, Crawford et al. (2004, p. 4 and references therein) reported survival of juveniles to their first breeding season was low, approximately 10 percent, and predation was one of several factors they cited as affecting juvenile survival. However, Connelly et al. (2011a, p. 64) point out that the estimate of 10 percent survival of juveniles likely is biased low, as at least two of the four studies that were the basis of this estimate were from areas with fragmented or otherwise marginal habitat.

Sage-grouse nests are subject to varying levels of predation. Predation can be total (all eggs destroyed) or partial (one or more eggs destroyed). However, hens abandon nests in either case (Coates 2007, p. 26). Gregg et al. (1994, p. 164) reported that over a 3-year period in Oregon, 106 of 124 nests (84 percent) were preyed upon (Gregg et al. 1994, p. 164). Non-predated nests had greater grass and forb cover than predated nests. Patterson (1952, p.104) reported nest predation rates of 41 percent in Wyoming. Holloran and Anderson (2003, p. 309) reported a predation rate of 12 percent (3 of 26) in Wyoming. In a 3-year study involving four study sites in Montana, Moynahan et al. (2007, p. 1777) attributed 131 of 258 (54 percent) of nest failures to predation in Montana, but the rates may have been inflated by the study design (Connelly et al. 2011a, p. 64). Re-nesting efforts may compensate for the loss of nests due to predation (Schroeder 1997, p. 938), but re-nesting rates are highly variable (Connelly et al. 2011a, p. 64). Therefore, re-nesting is unlikely to offset losses due to predation. Losses of breeding hens and young chicks to predation potentially can influence overall greater sage-grouse population numbers, as these two groups contribute most significantly to population productivity (Baxter et al. 2008, p. 185; Connelly et al, 2011a, p. 66).

Nesting success of greater sage-grouse is positively correlated with the presence of big sagebrush and grass and forb cover (Connelly et al. 2000, p. 971). Females actively select nest sites with these qualities (Schroeder and Baydack 2001, p. 25; Hagen et al. 2007, p. 46). Nest predation appears to be related to the amount of herbaceous cover surrounding the nest (Gregg et al. 1994, p. 164; Braun 1995; DeLong et al. 1995, p. 90; Braun 1998; Coggins 1998, p. 30; Connelly et al. 2000b, p. 975; Schroeder and Baydack 2001, p. 25; Coates and Delehanty 2008, p. 636) and shrub cover (Conover et al. 2010, p. 335). Loss of nesting cover from any source (e.g., grazing, fire) can reduce nest success and adult hen survival (Coates and Delehanty 2008, p. 636). However, Coates (2007, p. 149) found that badger predation was facilitated by nest cover as it attracts small mammals, a badger’s primary prey. Similarly, habitat alteration that reduces cover for young chicks can increase their rate of predation (Schroeder and Baydack 2001, p. 27).

In a review of published nesting studies, Connelly et al. (2011a, p. 58) reported that nesting success was greater in unaltered habitats versus altered habitats. Where greater sage-grouse habitat has been altered, the influx of predators can decrease annual recruitment into a population (Gregg et al. 1994, p. 164; Braun 1995; Braun 1998; DeLong et al. 1995, p. 91; Schroeder and Baydack 2001, p. 28; Coates 2007, p. 2; Hagen in press, p. 7). Ritchie et al. (1994, p. 125), Schroeder and Baydack (2001, p. 25), Connelly et al. (2004, p. 7-23), and Summers et al. (2004, p. 523) have reported that agricultural development, landscape fragmentation, and human populations have the potential to increase predation pressure on all life stages of greater sage-grouse by forcing birds to nest in less suitable or marginal habitats, increasing travel time through habitats where they are vulnerable to predation, and increasing the diversity and density of predators.

Abundance of red fox and corvids, which historically were rare in the sagebrush landscape, has increased in association with human-altered landscapes (Sovada et al. 1995, p. 5). In the Strawberry Valley of Utah, low survival of greater sage-grouse may have been due to an unusually high density of red foxes, which apparently were attracted to that area by anthropogenic activities (Bambrough et al. 2000). Survival rates of adult sage-grouse is this area have been correlated to red fox removal (UDWR 2011, pers. comm.). Ranches, farms, and housing developments have resulted in the introduction of nonnative predators including domestic dogs (Canis domesticus) and cats (Felis domesticus) into greater sage-grouse habitats (Connelly et al. 2004, p. 7-23). Local attraction of ravens to nesting hens may be facilitated by loss and fragmentation of native shrublands, which increases exposure of nests to potential predators (Aldridge and Boyce 2007, p. 522; Bui 2009, p. 32; Bui et al. 2010, p. 75; Coates and Delehanty 2010, p. 246). The presence of ravens was negatively associated with grouse nest and brood fate (Bui et al. 2010, p. 73).

Common ravens and sage-grouse have co-existed for approximately two million years (Bui et al. 2010, p. 75, and references therein). However, raven abundance has increased as much as 1500 percent in some areas of western North America since the 1960s (Coates and Delehanty 2010, p. 244 and references therein), and is linked with increases in human activity which provides supplemental sources food, water and nest sites (Bui et al. 2010, p. 74). Human-made structures in the environment increase the effect of raven predation, particularly in low canopy cover areas, by providing ravens with perches (Braun 1998, pp.145-146; Coates 2007, p. 155; Bui et al. 2010, p. 74). Reduction in patch size and diversity of sagebrush habitat, as well as the construction of fences, powerlines and other infrastructure also are likely to encourage the presence of the common raven (Coates et al. 2008, p. 426; Bui et al. 2010, p. 74). For example, raven counts have increased by approximately 200 percent along the Falcon-Gondor transmission line corridor in Nevada (Atamian et al. 2007, p. 2). Ravens contributed to lek disturbance events in the areas surrounding the transmission line (Atamian et al. 2007, p. 2), but as a cause of decline in surrounding sage-grouse population numbers, it could not be separated from other potential impacts, such as WNv. Nest success for this population, however, is exceptionally low, and a seasonally bimodal pattern of predation has been noted (NDOW 2011, pers. comm.). Holloran (2005, p. 58) attributed increased sage-grouse nest depredation to high corvid abundances, which resulted from anthropogenic food and perching subsidies in areas of natural gas development in western Wyoming. Bui (2009, p. 31) also found that ravens used road networks associated with oil fields in the same Wyoming location for foraging activities, but could not prove a causal link between raven occurrence and sage-grouse reproductive failure (Bui et al. 2010, p. 75). Holmes (unpubl. data) also found that common raven abundance increased in association with oil and gas development in southwestern Wyoming. The influence of synanthropic predators in the Wyoming Basin is important as this area has one of the few remaining clusters of sagebrush landscapes and the most highly connected network of sage-grouse leks (Knick and Hanser 2011, p.391). Raven abundance was strongly associated with sage-grouse nest failure in northeastern Nevada, with resultant negative effects on sage-grouse reproduction (Coates 2007, p. 130; Coates and Delehanty 2010, p. 240). The presence of high numbers of predators within a sage-grouse nesting area may negatively affect sage-grouse productivity without causing direct mortality. Coates (2007, p. 85-86) suggested that ravens may reduce the time spent off the nest by female sage-grouse, thereby potentially compromising their ability to secure sufficient nutrition to complete the incubation period.

As more suitable grouse habitat is converted to oil fields, agriculture and other exurban development, grouse nesting and brood-rearing become increasingly spatially restricted (Bui 2009, p. 32). High nest densities which result from habitat fragmentation or disturbance associated with the presence of edges, fencerows, or trails may increase predation rates by making foraging easier for predators (Holloran 2005, p. C37). In some areas even low but consistent raven presence can have a major impact on sage-grouse reproductive behavior (Bui 2009, p. 32). Leu and Hanser (2011, p. 269) determined that the influence of the human footprint in sagebrush ecosystems may be underestimated due to varying quality of spatial data. Therefore, the influence of ravens and other predators associated with human activities may be under-estimated.

Predator removal efforts have sometimes shown short-term gains that may benefit fall populations, but not breeding population sizes (Cote and Sutherland 1997, p. 402; Hagen 2011, p. 99; Leu and Hanser 2011, p. 270). Predator removal may have greater benefits in areas with low habitat quality, but predator numbers quickly rebound without continual control (Hagen 2011, p.99). Red fox removal in Utah appeared to increase adult sage-grouse survival (UDWR 2011, pers. comm.) and productivity, but the study did not compare these rates against other non-removal areas, so inferences are limited (Hagen 2011, p. 99). Slater (2003, p. 133) demonstrated that coyote control failed to have an effect on greater sage-grouse nesting success in southwestern Wyoming. However, coyotes may not be an important predator of sage-grouse. In a coyote prey base analysis, Johnson and Hansen (1979, p. 954) showed that sage-grouse and bird egg shells made up a very small percentage (0.4-2.4 percent) of analyzed scat samples. Additionally, coyote removal can have unintended consequences resulting in the release of mesopredators, many of which, like the red fox, may have greater negative impacts on sage-grouse (Mezquida et al. 2006, p. 752). Removal of ravens from an area in northeastern Nevada caused only short-term reductions in raven populations (less than 1 year) as apparently transient birds from neighboring sites repopulated the removal area (Coates 2007, p. 151). This conclusion is also supported by Bui et al.(2010, p. 75). Additionally, badger predation appeared to partially compensate for decreases in raven removal (Coates 2007, p. 152). In their review of literature regarding predation, Connelly et al. (2004, p. 10-1) noted that only two of nine studies examining survival and nest success indicated that predation had limited a sage-grouse population by decreasing nest success, and both studies indicated low nest success due to predation was ultimately related to poor nesting habitat. Bui et al. (2010, p. 75) suggested removal of anthropogenic subsidies (e.g., landfills, tall structures) may be an important step to reducing the presence of sage-grouse predators. Leu and Hanser (2011, p. 270) also argue that reducing the effects of predation on sage-grouse can only be effectively addressed by precluding these features.

Greater sage-grouse are adapted to minimize predation by cryptic plumage and behavior. Because sage-grouse are prey, predation will continue to be an effect on the species. Where habitat is not limited and is of good quality, predation is not a threat to the persistence of the species. However, sage-grouse may be increasingly subject to levels of predation that would not normally occur in the historically contiguous unaltered sagebrush habitats. The impacts of predation on greater sage-grouse can increase where habitat quality has been compromised by anthropogenic activities (exurban development, road development, etc.) (e.g. Coates 2007, p. 154, 155; Bui 2009, p. 16; Hagen 2011, p. 100). Landscape fragmentation, habitat degradation and human populations have the potential to increase predator populations through increasing ease of securing prey and subsidizing food sources and nest or den substrate (Bui et al. 2010, p. 75). Thus, otherwise suitable habitat may change into a habitat sink for grouse populations (Aldridge and Boyce 2007, p. 517). Anthropogenic influences on sagebrush habitats that increase suitability for ravens may limit sage-grouse populations (Bui et al. 2010, p. 75). Current land-use practices in the intermountain West favor high predator (in particular, raven) abundance relative to historical numbers (Coates et al. 2008, p. 426). The interaction between changes in habitat and predation may have substantial effects at the landscape level (Coates 2007, p. 3).

The studies presented here suggest that, in areas of intensive habitat alteration and fragmentation, sage-grouse productivity and, therefore, populations could be negatively affected by increasing predation. Predators could already be limiting sage-grouse populations where habitat has been fragmented by intense human activity in southwestern Wyoming and central and northeastern Nevada (Coates 2007, p. 131; Bui 2009, p. 33; NDOW 2011, in litt.). The influence of synanthropic predators in southwestern Wyoming may be particularly significant as this area has one of the few remaining sagebrush landscapes and the most highly connected network of sage-grouse leks (Wisdom et al. 2011, p. 469). Unfortunately, except for the few studies presented here, data are lacking that definitively link sage-grouse population trends with predator abundance. However, where habitats have been altered by human activities, we believe that predation could be limiting local sage-grouse populations. As more habitats face development, even dispersed development, we expect the risk of increased predation to spread, possibly with negative effects on the sage-grouse population trends. Studies of the effectiveness of predator control have failed to demonstrate an inverse relationship between the predator numbers and sage-grouse nesting success or populations numbers.

Except in localized areas where habitat is compromised, we found no evidence to suggest predation is limiting greater sage-grouse populations. However, landscape fragmentation is continuing to contribute to increased predation on this species.

D. The inadequacy of existing regulatory mechanisms:

Local Land Use Laws, Processes, and Ordinances

Approximately 31 percent of the sagebrush habitats within the sage-grouse MZs are privately owned (Table 1; Knick in press, p. 39) and are subject only to local regulations unless Federal actions are associated with the property (e.g., wetland modification, Federal subsurface owner). We have identified only one regulation at the local level that specifically addresses sage-grouse. Washington County, Idaho, Planning and Zoning has developed a draft Comprehensive Plan which states that the county fully supports all provisions developed for sage-grouse Idaho's West Central Local Working Group (Washington County Comprehensive Plan 2010, p. 34). The County also states that they will support the identification of important wildlife habitats and the protection of "species of concern", including the sage-grouse (Washington County Comprehensive Plan 2010, p. 51). However, no specific regulatory provisions for the protection of greater sage-grouse were provided, thereby limiting the effectiveness of this plan as a regulatory mechanism. Sage-grouse are mentioned in other county and local plans across the range, and some general recommendations were made regarding effects to sage-grouse associated with land uses. However, we could find no other examples of county-planning and enforceable zoning regulations specific to sage-grouse.

State Laws and Regulations

States have broad authority to regulate and protect wildlife within their borders. Each state across the range of the greater sage-grouse has laws and regulations that identify the need to conserve wildlife populations and habitat, including greater sage-grouse (Connelly et al. 2004, p. 2-22-11). As an example, in Colorado, "wildlife and their environment" are to be protected, preserved, enhanced and managed (Colorado Revised Statutes, Title 33, Article 1–101 in Connelly et al. 2004, p. 2-3). Laws and regulations in Oregon, Idaho, South Dakota, and California have similar provisions (Connelly et al. 2004, pp. 2-2 to 2-4, 2-6 to 2-8). However, these laws and regulations are general in nature and have not provided the protection to sage-grouse habitat necessary to protect the species from the specific threats described above.

All of the states within the range of the greater sage-grouse have state school trust lands that are managed to maximize income to support schools. With the exception of Wyoming (see discussion below), none of the states have specific regulations to ensure that the management of the state trust lands is consistent with the needs of sage-grouse. Thus there are currently no regulatory mechanisms on state trust lands to ensure conservation of the species.

Specific State regulations:
On September 26, 2008, the Governor of Nevada signed an executive order calling for the preservation and protection of sage-grouse habitat in the State of Nevada (Nevada Governor's Sage-Grouse Conservation Team 2010, p. 11). The executive order directs the NDOW to "continue to work with state and federal agencies and the interested public" to implement the Nevada sage-grouse conservation plan. The executive order also directs other State agencies to coordinate with the NDOW to implement the recommendations of the 2004 State Conservation plan for sage-grouse (Nevada Governor's Sage-grouse Conservation Team 2010, p. 11). Although directed specifically at sage-grouse conservation, the executive order is broadly worded and does not outline specific measures that will be undertaken to reduce threats and ensure conservation of sage-grouse in Nevada.

In 2010 the Nevada Governor's Sage-Grouse Conservation Team provided development standards to conserve sage-grouse and their associated habitats for any energy and infrastructure development in that state (Nevada Governor's Sage-Grouse Conservation Team 2010, entire). Their effort has resulted in the identification and designation of important sage-grouse habitats in Nevada. The Team further provides standards and best management practices for conservation of those areas based on the best available scientific information. However, there is no regulatory authority to ensure implementation of the standards and practices identified.

The California Environmental Quality Act (CEQA) (Public Resources Code sections 21000–21177), requires full disclosure of the potential environmental impacts of projects proposed in the State of California. Section 15065 of the CEQA guidelines requires a finding of significance if a project has the potential to “reduce the number or restrict the range of a rare or endangered plant or animal.” Under these guidelines sage-grouse are given the same protection as those species that are officially listed within the State. However, the lead agency for the proposed project has the discretion to decide whether to require mitigation for resource impacts, or to determine that other considerations, such as social or economic factors, make mitigation infeasible (CEQA section 21002). In the latter case, projects may be approved that cause significant environmental damage, such as destruction of endangered species, their habitat, or their continued existence. Therefore, protection of listed species through CEQA is dependent upon the discretion of the agency involved, and cannot be considered adequate protection for sage-grouse.

Wyoming’s Governor issued an executive order on August 1, 2008, mandating special management for all State lands within sage-grouse “Core Population Areas” (State of Wyoming 2008, entire). Core Population Areas are important breeding areas for sage-grouse in Wyoming as identified by the Wyoming “Governor’s Sage-Grouse Implementation Team” using biological data provided by the Wyoming Game and Fish Department. In addition to identifying Core Population Areas, the Team also recommended stipulations that should be placed on development activities to ensure that existing habitat function is maintained within those areas. Accordingly, the executive order prescribes special consideration for sage-grouse, including authorization of new activities only when the project proponent can identify that the activity will not cause declines in greater sage-grouse populations, in the Core Population Areas. These protections will apply to slightly less than 23 percent of all lands in Wyoming, but account for approximately 80 percent of the total estimated sage-grouse breeding population in the State. On August 7, 2008, the Wyoming Board of Land Commissioners approved the application of the Implementation Team’s recommended stipulations to all new development activities on State lands within the Core Population Areas. The executive order also applies to all activities requiring permits from the Wyoming’s Industrial Siting Council (ISC), including wind power developments on all lands regardless of ownership in the State of Wyoming. The application of the Governor’s order to the Wyoming ISC has the potential to provide significant regulatory protection for sage-grouse from adverse effects associated with wind development and other developments. In February 2010, the Wyoming State Legislature adopted a joint resolution endorsing Wyoming’s core area strategy as outlined in the Governor’ Executive Order 2008-2.

The Wyoming Governor’s executive order was re-issued on August 18, 2010 (Executive Order 2010-4) to incorporate new science and data, and adjustments to the core population areas based on ground-truthing and review by local sage-grouse working groups. In addition, the executive order included existing and new stipulations outlining restrictions on development within core areas and the identification of designated transmission corridors. The order has subsequently been revised to address ambiguities and concerns raised through its application. The new Governor of Wyoming, who assumed office in January, 2011 supports this effort and signed the new Executive Order on June 2, 2011.

Based on the provisions within the Executive Order, the Wyoming State Board of Land Commissioners voted to withdraw approximately 400,000 ha (approximately 1 million ac) of land within the sage-grouse core areas from potential wind development (State of Wyoming 2008, entire). The withdrawal order states that “there is no published research on the specific impacts of wind energy on sage-grouse,” and further states that permitting for wind development should require data collection on the potential effects of wind on sage-grouse. This action demonstrates a significant action in the State of Wyoming to address future development activities in core areas.

The protective measures associated with the Governor’s order do not extend to lands located outside the identified core areas but still within occupied sage-grouse habitat. In non-core areas, minimization measures would be implemented that are intended to maintain habitat conditions such that there is a 50 percent likelihood that leks will persist over time, and habitat connectivity between core areas is not lost (WGFD 2009, pp. 30-35). The Service is working in collaboration with the State of Wyoming Sage Grouse Implementation team and other entities to continue to review and refine ongoing activities in the core areas to ensure the integrity and purpose of the core area approach is maintained. The BLM in Wyoming is currently preparing an amendment for six resource management plans (RMPs) which will incorporate the provisions of the executive order and insure statewide compatibility with the objectives of the State's core area strategy (a.k.a. Key Habitat Areas), on all BLM lands in the state (approximately 7,284,000 ha (18 million ac.)). The amendment will apply to all new, but not existing developments on BLM lands. However, not all BLM lands will be included simply because some are already so developed they no longer provide sage-grouse habitat. This amendment, to be completed in 2012, will result in an effective regulatory mechanism on BLM lands in Wyoming. The remaining 4 RMPs in Wyoming are under revision, and will also incorporate the tenets of the core area strategy (see discussion below). These actions provide substantial regulatory protection for sage-grouse in previously undeveloped areas on Wyoming BLM lands. We believe that when fully realized, the executive order could ameliorate some threats to the greater sage-grouse in Wyoming.

Other states within the range of the greater sage-grouse are considering development of a similar (but not identical) core area "policy" (e.g. Oregon). The Bureau of Land Management recently provided a rangewide core area analysis tool to assist in conservation planning efforts (Doherty et al. in litt. 2010, entire). While core population areas have been identified in many states, we are unaware of any current policy or similar structure for active conservation of these core areas.

On April 22, 2009, the Governor of Colorado signed into law new rules for the Colorado Oil and Gas Conservation Commission (COGCC), the entity responsible for permitting oil and gas well development in Colorado (COGCC 2009, entire). These rules require that permittees and operators determine whether their proposed development location overlaps with "sensitive wildlife habitat", or is within a restricted surface occupancy (RSO) Area. For greater sage-grouse, areas within 1 km (0.6 mi) of an active lek are designated as RSOs, and surface area occupancy will be avoided except in cases of economic or technical infeasibility (CDOW, 2009, p. 12). Areas within approximately 6.4 km (4 mi) of an active lek are considered sensitive wildlife habitat (CDOW, 2009, p. 13) and the development proponent is required to consult with the CDOW to identify measures to 1) avoid impacts on wildlife resources, including sage-grouse; 2) minimize the extent and severity of those impacts that cannot be avoided; and 3) mitigate those effects that cannot be avoided or minimized (COGCC 2009, section 1202.a). The COGCC will consider CDOW's recommendations in the permitting decision, although the final permitting and conditioning authority remains with COGCC. The new rules will inevitably provide for greater consideration of the conservation needs of the species, but the potential decisions, actions, and exemptions can vary with each situation, and consequently there is substantial uncertainty as to the level of protection that will be afforded to greater sage-grouse.

The Colorado Division of Wildlife has developed Wildlife Mitigation Plans for oil and gas developments in at least one sage-grouse population (CDOW 2011, pers. comm.). These agreements are minimizing impacts to sage-grouse from energy development, including avoidance of key habitats and use of directional drilling. Over 200,000 acres of occupied habitats have been included to date. However, while these agreements are beneficial to sage-grouse conservation, they are voluntary and therefore their conservation benefit cannot be considered a regulatory mechanism.

Some States require landowners to control noxious weeds, a habitat threat to sage-grouse on their property, but the types of plants considered to be noxious weeds vary by State. For example, only Oregon, California, Colorado, Utah, and Nevada list Taeniatherum asperum (medusahead) as a noxious, regulated weed, but T. asperum is problematic in other States (e.g., Washington, Idaho). Colorado is the only western State that officially lists Bromus tectorum (cheatgrass) as a noxious weed (USDA 2009), but B. tectorum is invasive in many more States. These laws may provide some protection for sage-grouse in areas, although large-scale control of the most problematic invasive plants is not occurring, and rehabilitation and restoration techniques are mostly unproven and experimental (Pyke 2011, p. 544).

All State wildlife agencies across the range of the species manage greater sage-grouse as resident native game birds except for Washington (Connelly et al. 2004, p. 6-3; see discussion of hunting above). In Washington, the species has been listed as a State-threatened species since 1998 and is managed in accordance with the State's provisions for such species (Stinson et al. 2004, p. 1). States maintain flexibility in hunting regulations through emergency closures or season changes in response to unexpected events that affect local populations. Hunting regulations provide adequate protection for the birds but do not protect the habitat. Therefore, the protection afforded through the management flexibility in state management is limited.

Federal Laws and Regulations

Because it is not considered to be a migratory species, the greater sage-grouse is not included under the provisions of the Migratory Bird Treaty Act (16 U.S.C. 703-712). However, several Federal agencies have other legal authorities and requirements for managing sage-grouse or their habitat. Federal agencies are responsible for managing approximately 64 percent of the sagebrush habitats within the sage-grouse MZs in the United States (Knick 2011, p. 26, Table 1). Two Federal agencies with the largest land management authority for sagebrush habitats are the BLM and USFS. The U.S. Department of Defense (DOD), DOE, and other agencies in DOI have responsibility for lands and/or decisions that involve less than 5 percent of greater sage-grouse habitat (Table 1).

Bureau of Land Management

Knick (2011, p. 27, Table 3) estimates that about 51 percent of sagebrush habitat within the sage-grouse MZs is BLM-administered land; this includes approximately 24.9 million ha (about 61.5 million ac). The Federal Land Policy and Management Act of 1976 (FLPMA) (43 U.S.C. 1701 et seq.) is the primary Federal law governing most land uses on BLM-administered lands, and directs development and implementation of Resource Management Plans (RMPs) which direct management at a local level. RMPs are the basis for all actions and authorizations involving BLM-administered lands and resources. They authorize and establish allowable resource uses, resource condition goals and objectives to be attained, program constraints, general management practices needed to attain the goals and objectives, general implementation sequences, intervals and standards for monitoring and evaluating RMPs to determine effectiveness, and the need for amendment or revision (43 CFR 1601.0-5(k)). The RMPs also provide a framework and programmatic direction for implementation plans, which are site-specific plans written to regulate decisions made in a RMP. Examples include allotment management plans (AMPs) that address livestock grazing, oil and gas field development, travel management, and wildlife habitat management. If an RMP contains specific direction regarding sage-grouse habitat, conservation, or management, it represents a regulatory mechanism that has the potential to ensure that the species and its habitats are protected during permitting and other decision-making on BLM lands.

The greater sage-grouse is designated as a sensitive species on BLM lands across the species' range (Sell 2010, pers comm.). The management guidance afforded species of concern under BLM Manual 6840 – Special Status Species Management (BLM 2008f) states that "Bureau sensitive species will be managed consistent with species and habitat management objectives in land use and implementation plans to promote their conservation and to minimize the likelihood and need for listing under the ESA" (BLM 2008f, p. 05V). BLM Manual 6840 further requires that RMPs should address sensitive species, and that implementation "should consider all site-specific methods and procedures needed to bring species and their habitats to the condition under which management under the Bureau sensitive species policies would no longer be necessary" (BLM 2008f, p. 2A1). As a designated sensitive species under BLM Manual 6840, sage-grouse conservation must be addressed in the development and implementation of RMPs on BLM lands.

The BLM has regulatory authority over livestock grazing, OHV travel and human disturbance, infrastructure development, fire management, and energy development through FLPMA and the Mineral Leasing Act (MLA) (30 U.S.C. 181 et seq.). The RMPs provide a framework and programmatic guidance for AMPs that address livestock grazing. In addition to FLPMA, BLM has specific regulatory authority for grazing management provided at 43 CFR 4100 (Regulations on Grazing Administration Exclusive of Alaska). Livestock grazing permits and leases contain terms and conditions determined by BLM to be appropriate to achieve management and resource condition objectives on the public lands and other lands administered by the BLM, and to ensure that habitats are, or are making significant progress toward being restored or maintained for BLM special status species (43 CFR 4180.1(d)). Terms and conditions that are attached to grazing permits are generally mandatory. Across the range of sage-grouse, BLM required each BLM state office to adopt rangeland health standards and guidelines by which they measure allotment condition (43 CFR 4180 2(b)). Each state office developed and adopted their own standards and guidelines based on habitat type and other more localized considerations.

The rangeland health standards must address restoring, maintaining or enhancing habitats of BLM special status species to promote their conservation, and maintaining or promoting the physical and biological conditions to sustain native populations and communities (43 CFR 4180.2(e)(9) and (10)). BLM is required to take appropriate action no later than the start of the next grazing year upon determining that existing grazing practices or levels of grazing use are significant factors in failing to achieve the standards and conform with the guidelines (43 CFR 4180.2(c)).

The BLM's regulations require that corrective action be taken to improve rangeland condition when the need is identified; however, actions are not necessarily implemented until the permit renewal process is initiated for the noncompliant parcel. Thus, there may be a lag time between the allotment assessment when necessary management changes are identified, and when they are implemented. Although RMPs, AMPs, and the permit renewal process provide an adequate regulatory framework, whether or not these regulatory mechanisms are being implemented in a manner that conserves sage-grouse is unclear. The BLM's national internal data call indicates that there are lands within the range of sage-grouse that are not meeting the rangeland health standards necessary to conserve sage-grouse habitats. In some cases management changes should occur, but such changes have not been implemented (BLM 2008i).

The BLM uses regulatory mechanisms to address invasive species concerns, particularly through the National Environmental Policy Act (NEPA) process. For projects proposed on BLM lands, BLM has the authority to identify and prescribe best management practices for weed management; where prescribed, these measures must be incorporated into project design and implementation. Some common best management practices for weed management may include surveying for noxious weeds, identifying problem areas, training contractors regarding noxious weed management and identification, providing cleaning stations for equipment, limiting off-road travel, and reclaiming disturbed lands immediately following ground disturbing activities, among other practices. The effectiveness of these measures is not documented.

The BLM conducts treatments for noxious and invasive weeds on BLM lands, the most common being reseeding through the Emergency Stabilization and Burned Area Rehabilitation Programs. According to BLM data, 66 of 92 RMPs noted that seed mix requirements (as stated in RMPs, emergency stabilization and rehabilitation, and other plans) were sufficient to provide suitable sage-grouse habitat (e.g., seed containing sagebrush and forb species) (Carlson 2008a, pers. comm.). However, a sufficient seed mix does not assure that restoration goals will be met; many other factors (e.g., precipitation) influence the outcome of restoration efforts.

Invasive species control is a priority in many existing RMPs. For example, 76 of the RMPs identified in the BLM data call claim that the RMP (or supplemental plans/guidance applicable to the RMP) requires treatment of noxious weeds on all disturbed surfaces to avoid weed infestations on BLM managed lands in the planning area (Carlson 2008a, pers. comm.). Also, of the 82 RMPs that reference sage-grouse conservation, 51 of these specifically address fire, invasives, conifer encroachment, or a combination thereof

(Carlson 2008b, pers. comm.). More RMPs may be addressing invasives under another general restoration category. The 51 RMPs that address fire, invasives, and conifer encroachment provide nonspecific guidance on how to manage invasives (e.g. manage livestock in a way that enhances desirable vegetation cover and reduces the introduction of invasives) (Carlson 2008b, pers. comm.). The extent to which these measures are implemented depends in large part on funding, staff time, and other regulatory and non-regulatory factors. Therefore, we cannot assess their value as regulatory mechanisms for the conservation of the greater sage-grouse.

Herbicides also are commonly used on BLM lands to control invasives. In 2007, the BLM completed a programmatic EIS (72 FR 35718) and record of decision (72 FR 57065) for vegetation treatments on BLM-administered lands in the western United States. This program guides the use of herbicides for field-level planning, but does not authorize any specific on-the-ground actions. Site-specific NEPA analyses are still required at the project level and therefore it is not possible to determine the effectiveness of this tool in addressing invasive plant species in sage-grouse habitats.

The BLM is the primary Federal agency managing the United States energy resources on 102 million surface ha (253 million ac) and 283 million sub-surface ha (700 million ac) of mineral estate (BLM 2010). Public sub-surface estate can be under public or private (i.e., split-estate) surface. Over 7.3 million ha (18 million ac) of sage-grouse habitats on public lands are leased for oil, gas, coal, minerals, or geothermal exploration and development across the sage-grouse range (Service 2008f). Energy development, particularly non-renewable development, has primarily occurred within sage-grouse MZs I and II.

The BLM has the legal authority to regulate and condition oil and gas leases and permits under both FLPMA and the MLA. An amendment to the Energy Policy and Conservation Act of 1975 (42 U.S.C. 6201 et seq.) in 2000 (Energy Policy Act of 2000 (PL 106-469)) requires the Secretary of the Interior to conduct a scientific inventory of all onshore Federal lands to identify oil and gas resources underlying these lands (42 U.S.C. 6217). The Energy Policy Act of 2005 (42 U.S.C. 15801 et seq.) further requires the nature and extent of any restrictions or impediments to the development of such resources be identified and permitting and development be expedited on Federal lands (42 U.S.C. 15921). In addition, the 2005 Energy Policy Act orders the identification of renewable energy sources (e.g., wind, geothermal) and provides incentives for their development (42 U.S.C. 15851).

On October 23, 2009, nine Federal agencies signed a MOU to expedite the siting and construction of qualified electric transmission within the United States (Federal Agency MOU 2009). The MOU states that all existing environmental review and safeguard processes will be fully maintained. Therefore, we assume that this new MOU will not alter the regulatory processes (e.g., RMPs, project specific NEPA analysis) currently in place related to transmission siting on BLM lands.

Program-specific guidance for fluid minerals (including oil and gas) in the BLM planning handbook (BLM 2005b, Appendix C pp. 23-24) specifies that land use planning decisions will identify restrictions on areas subject to leasing, including closures, as well as lease stipulations. Stipulations are conditions that are made part of a lease when the environmental planning record demonstrates the need to accommodate various resources such as the protection of specific wildlife species. Stipulations advise the lease holder that a wildlife species in need of special management may be present in the area defined by the lease, and certain protective measures may be required in order to develop the mineral resource on that lease. Stipulations do not apply to the operation or maintenance of existing facilities, regardless of their proximity to sage-grouse breeding areas (BLM 2008h). Approximately 73 percent of leased lands in known sage-grouse breeding habitat have no stipulations at all (Service 2008f). The BLM stipulations most commonly attached to leases and permits are inadequate for the protection of sage-grouse, and for the long-term maintenance of their populations in those areas affected by oil and gas development activities (Holloran 2005, pp. 57-60; Walker et al. 2007a, p. 2651). In some locations, the BLM is incorporating recommendations and information from new scientific studies into management direction.

All stipulations must have waiver, exception, or modification criteria documented in the plan, and the least restrictive constraint to meet the resource protection objective should be used (BLM 2005b, Appendix C pp. 23-24). Waivers are permanent exemptions, and modifications are changes in the terms of the stipulation. The BLM reports the issuance of waivers and modifications as rare (BLM 2008i). Exceptions are a one-time exemption to a lease stipulation. For example, a company may be issued an exception to enter crucial winter habitat during a mild winter if an on-the-ground survey verifies that sage-grouse are not using the winter habitat or have left earlier than normal (BLM 2004, p. 86). In 2006 and 2007, of 1,716 mineral or right-of-way authorizations on Federal surface in 42 BLM planning areas no waivers were issued; 24 modifications were issued and 115 exceptions were granted, 72 of which were in the Great Divide planning area in Wyoming (BLM 2008i), one of the densest population concentrations for sage-grouse. However, we have no information regarding the impact of granting these modifications and exceptions on sage-grouse or their habitats.

Recently the BLM has begun developing guidance to minimize impacts of renewable energy production on public lands. A ROD for "Implementation of a Wind Energy Development Program and Associated Land Use Plan Amendments" (BLM 2005a, entire) was issued in 2005. The ROD outlines best management practices (BMPs) for the siting, development and operation of wind energy facilities on BLM lands. The voluntary guidance of the BMPs do not include measures specifically intended to protect greater sage-grouse, although they do provide the flexibility for such measures to be required through site-specific planning and authorization (BLM 2005a, p. 2). Oregon BLM has entered into a Memorandum of Understanding with the State of Oregon to document agency responsibilities and procedures to follow in conducting joint review of commercial wind energy development projects on BLM lands (p. 2). Unfortunately specifics of the MOU were not provided so we cannot assess its value for sage-grouse conservation. Additionally, MOUs are not legally binding documents, so their utility as a regulatory mechanism is limited.

There are 92 RMPs that include sage-grouse habitat throughout the species range. Many of these RMPs are under revision which was initiated due to the age of the current RMP and not specifically for incorporation of sage-grouse conservation measures. However, many BLM offices are using the revisions to incorporate these measures into their land management documents. For each revision, the planning process provides alternatives that incorporate varying degrees of conservation measures for sage-grouse and their habitats. Until an RMP revision is complete, we cannot determine the value of that planning document in providing adequate regulatory structures for sage-grouse conservation simply because each revision considers several alternatives with variable provisions for sage-grouse and sagebrush conservation.

In Colorado, 6 RMPs are being revised, and each has at least one alternative considering sage-grouse conservation actions. The preferred alternative for one RMP near completion does include strategies to maintain sustainable sage-grouse populations and habitats (CO BLM 2011, in litt.). Three additional RMPs are being amended to incorporate conservation measures for sage-grouse in light of proposed oil and gas and geothermal energy development. However, existing leases for those resources will not fall under any new protective stipulations (CO BLM 2011, in litt.). Four RMPs are being revised in Idaho, one of which contains extensive proposals for sage-grouse conservation, including the potential for designating Areas of Critical Environmental Concern (K. Womack, USFWS, 2011 pers. comm.). Two others include alternatives incorporating conservation measures from the State of Idaho's sage-grouse conservation plans. Three field offices in Montana are in the initial stages of developing new RMPs. These offices have been given guidance to incorporate common management guidelines for sage-grouse in the new RMPs, and should complement the State's efforts on designated core areas (MT BLM 2011, in litt.). The RMP for BLM lands in South Dakota is also being revised, but specific details relative to sage-grouse conservation were not provided (MT BLM 2011, in litt.). The NV BLM is revising 2 RMPs, but one has just been initiated and little information is currently available for review. For the other RMP at least one alternative includes incorporation of the State's Essential Habitat Map for sage-grouse, which designates areas of important sage-grouse habitats for exclusion of development, as well as designated utility corridors, and temporal and spatial protective buffers (NV BLM 2011, in litt). Stipulations for oil and gas and geothermal energy leasing are also being considered.

In Oregon, two RMPs are currently under revision and will incorporate the sage-grouse core areas designations that have been identified by the State. The RMPs will also incorporate the State's Sage-grouse Conservation Assessment and Strategy as an overall guidance document for sage-conservation actions of Oregon BLM administered lands. This strategy provides a framework for long-term conservation of Oregon sage-grouse populations with identified goals of no net loss of habitat and maintaining population levels at or above a 2003 baseline. One RMP is being revised in Utah, which will incorporate their habitat management policy for sage-grouse once that policy is finalized in mid-2011. The policy will identify conservation measures for sage-grouse, planning guidance, and suitable mitigation practices to help eliminate, reduce, or minimize threats to sage-grouse on BLM-administered lands in Utah (UT BLM 2011, in litt.). In addition to the RMP revision discussed under Wyoming's Core Area Strategy above, the four remaining RMPs in Wyoming are being revised to incorporate the provisions necessary to also comply with the State of Wyoming's core area strategy.

In addition to RMPs, BLM uses Instruction Memoranda (IM) to provide policy and instruction to district and field offices regarding specific resource issues. Implementation of IMs is required unless the IM itself provides discretion (Buckner 2009a, pers. comm.). However, IMs are short duration (1 to 2 years) and are intended to immediately address resource concerns or provide direction to staff until a threat passes or the resource issue can be addressed in a long-term planning document. Because of their short duration, their utility and certainty as a long-term regulatory mechanism may be limited if not regularly renewed. Four national IM's pertaining to sage-grouse are currently in effect. IM 2010-149 – Sage-grouse Conservation Related to Wildland Fire and Fuels Management – provides guidance and resources for conservation of important sage-grouse habitats and populations relative to fire management on BLM lands. This IM directs the BLM to prioritize conservation of important sage-grouse habitats, including during wildfire suppression. While we do not know the extent to which these directives alleviated the wildfire threat to sage-grouse during the 2008, 2009 and 2010 fire seasons, we believe that this strategic approach to ameliorating the threat of fire could provide significant conservation benefits to important sage-grouse habitats. The IM expires on September 30, 2011, and if not renewed or incorporated into policy, will have limited effectiveness. IM 2010-71 – Gunnison and Greater Sage-Grouse Management Consideration for Energy Development – identifies priority sage-grouse habitats and provides guidelines for habitat conservation for lease sale and development proposals relative to oil and gas, geothermal, oil shale, wind and solar energy development, and transmission project placement. This IM also provides the guidance for RMP revisions and amendments to analyze one or more alternatives that would exclude important sage-grouse habitats from these projects. The Colorado BLM State Director issued a clarification of this IM for State use (CO IM 2010-028), emphasizing continued coordination amongst all the State partners and the BLM in the implementation of local and state conservation plans. This state policy recognizes use of adaptive management relative to new research results, and local habitat and population information (CO BLM 2011, in litt.). Both the national and Colorado IM expire on September 30, 2011.

Concerns with fences and wind development projects are addressed in IM 2010-22 – Managing Structures for the Safety of Sage-grouse, Sharp-tailed grouse, and Lesser Prairie-chicken. This IM identifies recommended practices for marking, or otherwise managing fence and meteorological tower collisions. Idaho BLM has issued a similar state IM, addressing siting of meteorological towers, and marking of the associated guy wires, as well as fencing (ID IM 2009-006). While these IMs provide regulatory protection for sage-grouse relative to fencing and wind, they both expire on September 30, 2011. IM 2010-84 – Grasshopper and Mormon Cricket Treatments within Sage-grouse Habitat – identifies standard operating procedures and management actions to provide adequate grasshopper and Mormon cricket control to rangelands while still providing an adequate prey resource for sage-grouse on BLM lands. This IM also expires on September 30, 2011, limiting its long-term effectiveness.

In addition to the National and State IMs discussed above, Idaho BLM has issued ID IM 2010-005, which directs managers to use an infrastructure conflict map during early project development to aid in siting, project analyses and mitigation planning (ID BLM 2011, in litt.). Use of the conflict map could be very effective at reducing, or eliminating new impacts to sage-grouse habitats. Montana BLM issued MT IM

2010-017 in November, 2009, which directs all MT state offices to develop alternatives in ongoing and future RMP revisions for activities that may affect the greater sage-grouse. The IM provides guidance to mitigate impacts and BMPs for all proposed projects and activities. The effectiveness of this will be based on how it is interpreted and applied in each of the field offices. The IM is based on an approach based on core areas in Montana, similar to the approach implemented more formally in Wyoming. Therefore, it could be effective in reducing impacts to sage-grouse habitat in the short term on BLM lands in Montana. Unfortunately, the IM applies only to ongoing and future RMPs, and does not apply to activities authorized under existing RMPs. Both the IM in Idaho and Montana expire on September 30, 2011, potentially limiting their long-term effectiveness unless they are either renewed, or incorporated into policy or RMPs at that time.

The BLM also issues Information Bulletins (IBs), which are used to disseminate information of interest to BLM employees. They do not contain BLM policy, directives, or instructional material, and therefore have no regulatory component. Idaho BLM issued an IB in July, 2010 (ID IB 2010-039), which describes recommended wildlife seasonal restrictions and spatial buffers for use in project planning. For sage-grouse the IB emphasizes avoidance of important seasonal habitats through siting, and recommends a 6.4 km (4-mile) disturbance buffer during lekking and nesting seasons to reduce disturbance breeding sage-grouse. While the IB provides good conservation information, it lacks any regulatory authority, thereby limiting its effectiveness for long-term conservation. We are unaware of any other IBs that address sage-grouse or their habitats.

Montana BLM has deferred all or portions of 509 oil and gas parcels (totaling approximately 251,000 ha (620,000 ac)) until RMP revisions can be completed that will include new stipulations to protect sage-grouse (MT BLM 2011, in litt.). Similarly, Utah BLM deferred all or portions of 111 oil and gas parcels (encompassing approximately 75,000 ha (185,500 ac)) in crucial sage-grouse habitat until adequate planning or NEPA analysis can be completed (UT BLM 2011, in litt.). Deferral of leases until adequate conservation measures for sage-grouse can be incorporated should reduce potential impacts from energy development. However, uncertainty regarding the final disposition of these deferrals precludes us from considering these actions as a regulatory mechanism. In Nevada the BLM has closed 15 parcels (21,448 ha (53,000 acres)) for geothermal leasing or the associated right-of-ways due to sage-grouse concerns (NV BLM 2011, in litt.). Permanently removing parcels from energy development does provide a significant regulatory mechanism for the protection of sage-grouse and their habitats.

Summary – BLM

The BLM manages the majority of greater sage-grouse habitats across the range of the species. The BLM has broad regulatory authority to plan and manage all land use activities on their lands including travel management, energy development, grazing, fire management, invasive species management, and a variety of other activities. Land planning documents (RMPs) provide the necessary regulatory structure to ensure long-term conservation of the greater sage-grouse. To date, few RMPs have provided the adequate protective measures for conservation of this species. However, several RMPs are being revised, and many will be incorporating regulatory conservation measures for sage-grouse during that process. Additionally, many more RMPs are being amended for the same purpose. Until this process is completed, we cannot consider existing regulatory mechanisms to be sufficient for long-term conservation. But, we recognize the significant progress made in the initiation of these revisions and amendments.

The issuance of IMs, at both the national and state levels, does provide a short-term regulatory mechanism to conserve sage-grouse. Many of these policy documents are serving as placeholders for developing RMP revisions and are providing some regulatory protections. However, their short duration, limited areas of application, and uncertainty of renewal upon expiration limit their effectiveness as a long-term regulatory mechanism. Deferral of leases and development of MOUs with partners are also providing conservation benefits for sage-grouse. However, the long-term disposition of those actions is unknown and cannot be considered an adequate regulatory mechanism.

USDA Forest Service

The USFS has management authority for 8 percent of the sagebrush area within the sage-grouse MZs (Table 1; Knick 2011, p. 26). The USFS estimated that sage-grouse occupy about 5.2 million ha (12.8 million ac) on national forest lands in the western United States (USFS 2008 Appendix 2, Table 1). Twenty-six of the 33 National Forests or Grasslands across the range of sage-grouse contain moderately or highly important seasonal habitat for sage-grouse (USFS 2008 Appendix 2, Table 2). Management of activities on national forest system lands is guided principally by the National Forest Management Act (NFMA) (16 U.S.C. 1600-1614, August 17, 1974, as amended 1976, 1978, 1980, 1981, 1983, 1985, 1988 and 1990). NFMA specifies that the USFS must have a land and resource management plan (LRMP) (16 U.S.C. 1600) to guide and set standards for all natural resource management activities on each National Forest or National Grassland. All of the LRMPs that currently guide the management of sage-grouse habitats on USFS lands were developed using the 1982 implementing regulations for land and resource management planning (1982 Rule, 36 CFR 219).

Greater sage-grouse is designated as sensitive species on USFS lands across the range of the species (USFS 2008, pp. 25-26). Designated sensitive species require special consideration during land use planning and activity implementation to ensure the viability of the species on USFS lands and to preclude any population declines that could lead to a Federal listing (USFS 2008, p. 21). Additionally, sensitive species designations require analysis for any activity that could have an adverse impact to the species, including analysis of the significance of any adverse impacts on the species, its habitat, and overall population viability (USFS 2008, p. 21). The specifics of how sensitive species status has conferred protection to sage-grouse on USFS lands varies significantly across the range, and is largely dependent on LRMPs and site-specific project analysis and implementation. Fourteen forests identify greater sage-grouse as a Management Indicator Species (USFS 2008, Appendix 2, Table 2), which requires them to establish objectives for the maintenance and improvement of habitat for the species during all planning processes, to the degree consistent with overall multiple use objectives of the alternative (1982 Rule, 36 CFR 219.19(a)). Of the 33 National Forests that manage greater sage-grouse habitat, 16 do not specifically address sage-grouse management or conservation in their Forest Plans, and only 6 provide a high level of detail specific to sage-grouse management (USFS 2008, Appendix 2, Table 4). Thunder Basin Grasslands, on the Medicine Bow-Routt National Forest in northeast Wyoming is currently amending their LRMP that will implement conservation measures to conserve sage-grouse habitats (USFS 2011, Table 3). The primary purpose of the amendment is to update the prairie dog strategy for the Grasslands, and specific details regarding sage-grouse were not presented. Therefore, we are not able to determine if the amendment provides an adequate regulatory mechanism for sage-grouse conservation on that Grassland.

Almost all of the habitats that support sage-grouse on USFS lands also are open to livestock grazing (USFS 2008, p. 39). Under the Range Rescissions Act of 1995 (P.L. 104-19), the USFS must conduct a NEPA analysis to determine whether grazing should be authorized on an allotment, and what resource protection provisions should be included as part of the authorization (USFS 2008, p. 33). The USFS reports that they use the sage-grouse habitat guidelines developed in Connelly et al. (2000) to develop desired condition and livestock use standards at the project or allotment level. However, USFS also reported that the degree to which the recommended sage-grouse conservation and management guidelines were incorporated and implemented under Forest Plans varied widely across the range (USFS 2008, p. 45). We do not have the results of rangeland health assessments or other information regarding the status of USFS lands that provide habitat to sage-grouse and, therefore, cannot assess the efficacy in conserving this species. However, the White River Forest is in the process of closing three range allotments to minimize impacts on occupied sage-grouse habitats (USFS 2011, Table 3).

Energy development occurs on USFS lands, although to a lesser extent than on BLM lands. Through NFMA, LRMPs, and the On-Shore Oil and Gas Leasing Reform Act (1987; implementing regulations at 36 CFR 228, subpart E), the USFS has the authority to manage, restrict, or attach protective measures to mineral and other energy permits on USFS lands. Similar to BLM, existing protective standard stipulations on USFS lands include avoiding construction of new wells and facilities within 0.4 km (0.25 mi), and noise or activity disturbance within 3.2 km (2.0 mi) of active sage-grouse leks during the breeding season. As described above, this buffer is inadequate to prevent adverse impacts to sage-grouse populations. For most LRMPs where energy development is occurring, these stipulations also apply to hard mineral extraction, wind development, and other energy development activities in addition to fluid mineral extraction (USFS 2008, Appendix 1, entire). The USFS is a partner agency with the BLM on the draft programmatic EIS for geothermal energy development described above. The Record of Decision for the EIS does not amend relevant LRMPs and still requires project-specific NEPA analysis of geothermal energy applications on USFS lands (BLM and USFS 2008b, p. 3).

Since October 2009, all National Forests within the range of the sage-grouse have either completed, or proposed Travel Management Plans for motorized vehicles. The plans can include closure of motorized routes near leks and other seasonally important sage-grouse habitats. Some routes have been obliterated and re-planted with sagebrush (USFS 2011, Table 3). No information on specific locations or actions was provided, and therefore we are unable to assess the impacts of these Travel Management Plans on sage-grouse conservation. In a July, 2010 letter, the Chief of the Forest Service provided guidance for the management and conservation of sage-grouse and their habitats on Forest Service lands (USFS 2011, Table 3). Again, specific information was lacking and there is no information regarding the impacts of this direction on sage-grouse or their habitats.

The land use planning process and other regulations available to the USFS give it the authority to adequately address the needs of sage-grouse, although the extent to which they do so varies widely across the range of the species. We do not have information regarding the current land health status of USFS lands in relation to the conservation needs of greater sage-grouse; thus, we cannot assess whether existing conditions adequately meet the species' habitat needs.

Other Federal Agencies

Other Federal agencies in the DOD, DOE, and DOI (including the Bureau of Indian Affairs, the Service, and National Park Service) are responsible for managing less than 5 percent of sagebrush lands within the United States (Knick 2011 p. 26). Regulatory authorities and mechanisms relevant to these agencies' management jurisdictions include the National Park Service Organic Act (39 Stat. 535; 16 U.S.C. 1, 2, 3 and 4), the National Wildlife Refuge System Administration Act (16 U.S.C. 668dd-668ee), and the Department of the Army's Integrated Natural Resources Management Plans for their facilities within sage-grouse habitats. However, most of these agencies do not manage specifically for greater sage-grouse on their lands, except in localized areas (e.g., specific wildlife refuges, reservations).

The USDA Farm Service Agency manages the Conservation Reserve Program (CRP) which pays landowners a rental fee to plant permanent vegetation on portions of their lands, taking them out of agricultural production (Schroeder and Vander Haegen 2011, p.519). These lands are put under contract, typically for a 10-year period (Walker 2009, pers. comm.). In some areas across the range of sage-grouse, and particularly in Washington (Schroeder and Vander Haegen 2011, p. 527), CRP lands provide important habitat for the species. Under the 2008 Farm Bill, several changes could reduce the protection that CRP lands afford sage-grouse. An interim rule to implement the 2008 Farm Bill CRP provisions (75 FR 44067) identified several items that may affect the ability of CRP lands to provide suitable habitat for sage-grouse. However, many of the new permissible uses will be permitted with a concurrent reduction in payment to the enrollee, and while maintaining the conservation purposes of the contract (75 FR 44068). Permissive uses now include managed harvest and grazing, including the addition of a biomass harvest, prescribed grazing to control invasive species, commercial use of forage in response to a drought or other emergency, and wind turbine installation. Additionally, the total acreage that can be enrolled in the CRP program at any time has been reduced from 15.9 million ha (39.2 million ac) to 12.9 million ha (32 million ac) for 2010-2012 (USDA 2009a, p. 1), and no more than 25 percent of the agricultural lands in any county can now be enrolled under CRP contracts, although there are provisions to avoid this cap if permission is granted by the County government (Walker 2009, pers. comm.; 75 FR 44068). These changes could affect the quantity and quality of CRP lands serving as sage-grouse habitat. However, we received no information regarding the amount of

CRP lands currently providing sage-grouse habitat that will potentially be affected by these changes. Thus, we cannot assess to what extent these changes may change the quantity or quality of CRP land available for sage-grouse.

Canadian Federal and Provincial Laws and Regulations

Greater sage-grouse are federally protected in Canada as an endangered species under schedule 1 of the Species at Risk Act (SARA; Canada Gazette, Part III, Chapter 29, Volume 25, No. 3, 2002). Passed in 2002, SARA is similar to the ESA and allows for habitat regulations to protect sage-grouse (Aldridge and Brigham 2003, p. 31). The species is also listed as endangered at the provincial level in Alberta and Saskatchewan, and neither province allows harvest (Aldridge and Brigham 2003, p. 31). In Saskatchewan, sage-grouse are protected under the Wildlife Habitat Protection Act, which protects sage-grouse habitat from being sold or cultivated (Aldridge and Brigham 2003, p. 32). In addition, sage-grouse are listed as endangered under the Saskatchewan Wildlife Act, which restricts development within 500 m (1,640 ft) of leks and prohibits construction within 1,000 m (3,281 ft) of leks between March 15 and May 15 (Aldridge and Brigham 2003, p. 32). As stated above, these buffers are inadequate to protect sage-grouse from disturbance. In Alberta, individual birds are protected, but their habitat is not (Aldridge and Brigham 2003, p. 32). Thus, although there are some protections for the species in Canada, they are not sufficient to assure conservation of the species.

Summary

No current local land use or development planning regulations provide adequate protection to sage-grouse from development or uses that affect the quantity and quality of sagebrush habitats. Changes incorporated into the 2008 Farm Bill are likely to negatively impact private lands currently enrolled in the CRP program that are providing sage-grouse habitats. States within the range of this species regulate them as a gamebird species, with incorporation of adaptive harvest management strategies to address local population or habitat concerns. Beyond harvest regulations, only two states Wyoming and Colorado have implemented State regulations regarding energy development that could provide significant protection for greater sage-grouse. In Wyoming the regulations do not apply to existing leases, or to habitats outside of core areas. Thus, sage-grouse may continue to experience population-level impacts associated with activities (e.g., energy development) in Wyoming. In Colorado, the regulations describe a required process rather than a specific measure that can be evaluated, and Wildlife Mitigation Plans, while contributing to sage-grouse conservation, are voluntary agreements.

The majority of sage-grouse habitat in the United States is managed by Federal agencies (Table 1). The BLM and USFS have the legal authority through their RMPs and LRMPs (respectively) to regulate land use activities on their respective lands (cumulatively approximately 59 percent of the extant sage-grouse habitats). The BLM is actively pursuing RMP revisions and amendments, many of which will address sage-grouse conservation. However, none have been completed and therefore final alternatives and their resultant effects on grouse cannot be assessed. The development of Travel Management Plans on Forest Service lands may provide benefits in those areas where motorized travel impacts the species. However, we received no information on currently realized benefits. Guidance from the Chief of the Forest Service for the management and conservation of sage-grouse and their habitats on Forest Service lands lacked specific information and provided no regulatory mechanisms for implementation. We found no regulatory mechanisms currently in place to address sage-grouse conservation on other Federal lands.

Based on our review of the best scientific and commercial information available, we conclude that existing regulatory mechanisms are inadequate to protect the greater sage-grouse. While many mechanisms are proposed, they are incomplete, and their final disposition is unknown.

E. Other natural or manmade factors affecting its continued existence:

<u>Pesticides</u>

A discussion regarding pesticides no longer licensed for use (e.g. dieldrin) and their impacts to sage-grouse can be found in our March 2010 status review (75 FR 13982-13983). We currently do not have any information to show that the banned pesticides are presently having negative impacts to sage-grouse populations through either illegal use or residues in the environment.

Game birds that ingested sub-lethal levels of permitted pesticides have been observed exhibiting abnormal behavior that may lead to a greater risk of predation (Dahlen and Haugen 1954, p. 477; McEwen and Brown 1966, p. 609; Blus et al. 1989, p. 1141). McEwen and Brown (1966, p. 689) reported that wild sharp-tailed grouse poisoned by malathion (and dieldrin) exhibited depression, dullness, slowed reactions, irregular flight, and uncoordinated walking. Although no research has explicitly studied the indirect levels of mortality from sub-lethal doses of pesticides (e.g., predation of impaired birds), it has been assumed to be the reason for mortality among some study birds (McEwen and Brown 1966 p. 609; Blus et al. 1989, p. 1142; Connelly and Blus 1991, p. 4). Both Post (1951, p. 383) and Blus et al. (1989, p. 1142) located depredated sage-grouse carcasses in areas that had been treated with insecticides. Exposure to these insecticides may have predisposed sage-grouse to predation. Sage-grouse mortalities also were documented in a study where they were exposed to strychnine bait type used to control small mammals (Ward et al. 1942 as cited in Schroeder et al. 1999, p. 16).

Cropland spraying to control agricultural pests may affect sage-grouse populations that are not adjacent to agricultural areas, given the distances traveled by females with broods from nesting to late brood-rearing areas (Knick et al. 2011, p. 211). The actual footprint of this effect cannot be estimated, because the distances traveled to get to irrigated and sprayed fields are unknown (Knick et al. 2011, p. 211). Similarly, actual mortalities from pesticides may be underestimated if sage-grouse disperse from agricultural areas after exposure.

Although a reduction in insect population levels resulting from insecticide application can potentially affect nesting sage-grouse females and chicks (Willis et al. 1993, p. 40; Schroeder et al. 1999, p. 16), we have no information as to whether the loss of prey items impacts survivorship or productivity of the greater sage-grouse. Eng (1952, pp. 332,334) noted that after a pesticide was sprayed to reduce grasshoppers, songbird and corvid nestling deaths ranged from 50 to 100 percent depending on the chemical used, and stated it appeared that nestling development was adversely affected due to the reduction in grasshoppers. Potts (1986 as cited in Connelly and Blus 1991, p. 93) determined that reduced food supply resulting from the use of pesticides ultimately resulted in high starvation rates of partridge chicks (Perdix perdix). In a similar study on partridges, Rands (1985, pp. 51-53) found that pesticide application adversely affected brood size and chick survival by reducing chick food supplies.

Three approved insecticides, carbaryl, diflubenzuron, and malathion, are currently available for application across the extant range of sage-grouse as part of implementation of the Rangeland Grasshopper and Mormon Cricket Suppression Control Program, under the direction of the Animal and Plant Health Inspection Service (APHIS) (APHIS 2004, entire). Carbaryl is applied as bait, while diflubenzuron and malathion are sprayed. APHIS requires that application rates be in compliance with EPA regulations, and APHIS has general guidelines for buffer zones around sensitive species habitats. These pesticides are only applied for grasshopper and Mormon cricket (Anabrus simplex) control when requested by private landowners (APHIS 2004, p. 2). Due to delays in developing nationwide protocols for application procedures, APHIS did not perform any grasshopper or Mormon cricket suppression activities in 2006, 2007, or 2008 (Gentle 2008, pers. comm.).

In the Rangeland Grasshopper and Mormon Cricket Suppression Program Final Environmental Impact Statement—2002 (p.10), APHIS concluded that there "is little likelihood that the insecticide APHIS would use to suppress grasshoppers would be directly or indirectly toxic to sage-grouse. Treatments would typically not reduce the number of grasshoppers below levels that are present in non-outbreak years." APHIS (2002, p. 69) stated that although "malathion is also an organophosphorus insecticide and carbaryl is a carbamate insecticide, malathion and carbaryl are much less toxic to birds" than other insecticides associated with effects to sage-grouse or other wildlife. The APHIS risk assessment (pp. 122-184) for this EIS determined that the grasshopper treatments would not directly affect sage grouse. As to potential effects on prey abundance, APHIS noted that during "grasshopper outbreaks when grasshopper densities can be 60 or more per square meter (Norelius and Lockwood, 1999), grasshopper treatments that have a 90 to 95 percent mortality still leave a density of grasshoppers (3 to 6) that is generally greater than the average density found on rangeland, such as in Wyoming, in a normal year (Schell and Lockwood, 1997)." Control efforts for grasshoppers in Wyoming in 2010 were intensive, but use of the Reduce Agent Area Treatments (RAATs) methods for treatment was used to minimize impacts to sage-grouse (WGFD 2011, in litt..).

Herbicide applications can kill sagebrush and forbs important as food sources for sage-grouse (Carr 1968 as cited in Call and Maser 1985, p. 14). The greatest impact resulting from a reduction of either forbs or insect populations is for nesting females and chicks due to the loss of potential protein sources that are critical for successful egg production and chick nutrition (Johnson and Boyce 1991, p. 90; Schroeder et al. 1999, p. 16). A comparison of applied levels of herbicides with toxicity studies of grouse, chickens, and other gamebirds (Carr 1968, as cited in Call and Maser 1985, p. 15) concluded that herbicides applied at recommended rates should not result in sage-grouse poisonings.

In summary, pesticides can result in direct mortality of individuals, and also can reduce the availability of food sources, which in turn could contribute to mortality of sage-grouse. Despite the potential effects of pesticides, we could find no information to indicate that the use of these chemicals, at current levels, negatively affects greater sage-grouse population numbers.

<u>Contaminants</u>

Greater sage-grouse exposure to various types of environmental contaminants may potentially occur as a result of agricultural and rangeland management practices, mining, energy development and pipeline operations, nuclear energy production and research, and transportation of materials along highways and railroads.

A single greater sage-grouse was found covered with oil and dead in a wastewater pit associated with an oil field development in 2006; the site was in violation of legal requirements for screening the pit (Domenici 2008, pers. comm.). To the extent that this source of mortality occurs, it would be most likely in MZ I and II, as those zones are where most of the oil and gas development occurs in relation to occupied sage-grouse habitat. The extent to which such mortality to greater sage-grouse is occurring is extremely difficult to quantify due to difficulties in retrieving and identifying oiled birds and lack of monitoring. We expect that the number of sage-grouse occurring in the immediate vicinity of such wastewater pits would be small due to the typically intense human activity in these areas, the lack of cover around the pits, and the fact that sage-grouse do not require free water. Most bird mortalities recorded in association with wastewater pits are water-dependent species (e.g., waterfowl), whereas dead ground-dwelling birds (such as the greater sage-grouse) are rarely found at such sites (Domenici 2008, pers. comm.). However, if the wastewater pits are not appropriately screened, sage-grouse may have access to them and could ingest water and/or become oiled while pursing insects. If these birds then return to sagebrush cover and die their carcasses are unlikely to be found as only the pits are surveyed. The effects of areal pollutants resulting from oil and gas development on greater sage-grouse are discussed under the energy development section in Factor A.

Numerous gas and oil pipelines occur within the occupied range of several populations of the species. Exposure to oil or gas from pipeline spills or leaks could cause mortalities or morbidity to greater sage-grouse. Similarly, given the extensive network of highways and railroad lines that occur throughout the range of the greater sage-grouse, there is some potential for exposure to contaminants resulting from spills or leaks of hazardous materials being conveyed along these transportation corridors. We found no documented occurrences of impacts to greater sage-grouse from such spills, and we do not expect they are a significant source of mortality because these types of spills occur infrequently and involve only a small area that might be within the occupied range of the species.

Exposure of sage-grouse to radionuclides (radioactive atoms) has been documented at the DOE’s Idaho National Engineering Laboratory in eastern Idaho. Although radionuclides were present in greater sage-grouse at this site, there were no apparent harmful effects to the population (Connelly and Markham 1983, pp. 175-176). There is one site in the range formerly occupied by the species (Nuclear Energy Institute 2004), and construction is scheduled to begin on a new nuclear power plant facility in 2009 in Elmore County, Idaho, near Boise (Nuclear Energy Institute 2008) in MZ IV. At this new facility and any other future facilities developed for nuclear power, if all provisions regulating nuclear energy development are followed, it is unlikely that there will be impacts to sage-grouse as a result of radionuclides or any other nuclear products.

Recreational Activities

Boyle and Samson (1985, pp. 110-112) determined that non-consumptive recreational activities can degrade wildlife resources, water, and the land by distributing refuse, disturbing and displacing wildlife, increasing animal mortality, and simplifying plant communities. Sage-grouse response to disturbance may be influenced by the type of activity, recreationist behavior, predictability of activity, frequency and magnitude, activity timing, and activity location (Knight and Cole 1995, p. 71). Examples of recreational activities in sage-grouse habitats include hiking, camping, pets, and off-highway vehicle (OHV) use. We have not located any published literature concerning measured direct effects of recreational activities on greater sage-grouse, but can infer potential impacts from studies on related species and from research on non-recreational activities. Baydack and Hein (1987, p. 537) reported displacement of male sharp-tailed grouse at leks from human presence resulting in loss of reproductive opportunity during the disturbance period. Female sharp-tailed grouse were observed at undisturbed leks while absent from disturbed leks during the same time period (Baydack and Hein 1987, p. 537). Disturbance of incubating female sage-grouse could cause displacement from nests, increased predator risk, or loss of nests. However, disruption of sage-grouse during vulnerable periods at leks, or during nesting or early brood rearing could affect reproduction or survival (Baydack and Hein 1987, pp. 537-538).

Sage-grouse avoidance of activities associated with energy field development (e.g., Holloran 2005, pp. 43,53,58; Doherty et al. 2008, p. 194) suggests these birds are likely disturbed by any persistent human presence. Additionally, Aldridge et al. (2008, p. 988) reported that the density of humans in 1950 was the best predictor of extirpation of greater sage-grouse. The authors also determined that sage-grouse have been extirpated in virtually all counties reaching a human population density of 25 people/km2 (65people/mi2) by 1950. However, their analyses considered all impacts of human presence and did not separate recreational activities from other associated activities and infrastructure. The presence of pets in proximity to sage-grouse can result in sage-grouse mortality or disturbance, and increases in garbage from human recreationists can attract sage-grouse predators and help maintain their numbers at increased levels. Leu et al. (2008, p. 1133) reported that slight increases in human densities in ecosystems with low biological productivity (such as sagebrush) may have a disproportionally negative impact on these ecosystems due to the potentially reduced resiliency to anthropogenic disturbance.

Indirect effects to sage-grouse from recreational activities include impacts to vegetation and soils, and facilitating the spread of invasive species. Payne et al. (1983, p. 329) studied off-road vehicle impacts to rangelands in Montana, and found long-term (2 years) reductions in sagebrush shrub canopy cover as the result of repeated trips in the area. Increased sediment production and decreased soil infiltration rates were observed after disturbance by motorcycles and four-wheel drive trucks on two desert soils in southern

Nevada (Eckert et al. 1979, p. 395), and noise from these activities can cause disturbance (Knick et al. 2011, p.219).

Recreational use of OHVs is one of the fastest-growing outdoor activities. In the western United States, greater than 27 percent of the human population used OHVs for recreational activities between 1999 and 2004 (Knick et al., 2011, p. 217). Knick et al. (2011, p. 203) reported that widespread motorized access for recreation subsidized predators adapted to humans and facilitated the spread of invasive plants. Any high-frequency human activity along established corridors can affect wildlife through habitat loss and fragmentation (Knick et al. 2011, p. 219). The effects of OHV use on sagebrush and sage-grouse have not been directly studied (Knick et al. 2011, p. 219). However, a review of local sage-grouse conservation plans indicated that local working groups considered off-road vehicle use to be a risk factor in many areas.

We are unaware of scientific reports documenting direct mortality of greater sage-grouse through collision with off-road vehicles. Similarly, we did not locate any scientific information documenting instances where snow compaction as a result of snowmobile use precluded greater sage-grouse use, or affected their survival in wintering areas. Off-road vehicle or snowmobile use in winter areas may increase stress on birds and displace sage-grouse to less optimal habitats. However, there is no empirical evidence available documenting these effects on sage-grouse, nor could we find any scientific data supporting the possibility that stress from vehicles during winter is limiting greater sage-grouse populations.

Given the continuing influx of people into the western United States (see discussion under Urbanization, Factor A; Leu and Hanser, 2011, p. 255), which is contributed to in part by access to recreational opportunities on public lands, we anticipate effects from recreational activity will continue to increase.

Life History Traits Affecting Population Viability

Sage-grouse have comparatively low reproductive rates and high annual survival relative to other game birds (Schroeder et al. 1999 pp. 11, 14; Connelly et al. 2000a, pp. 969-970), resulting in slower potential or intrinsic population growth rates. Therefore, recovery of populations after a decline may require years. Also, as a consequence of their site fidelity to breeding and brood-rearing habitats (Lyon and Anderson 2003, p. 489), measurable population effects may lag behind negative habitat impacts (Wiens and Rotenberry 1985, p. 666). While these natural history characteristics would not limit sage-grouse populations across large geographic scales under historical conditions of extensive habitat, they may contribute to local population declines when humans alter habitats or mortality rates.

Sage-grouse have one of the most polygamous mating systems observed among birds (Deibert 1995, p. 92). Asymmetrical mate selection (where only a few of the available members of one sex are selected as mates) should result in reduced effective population sizes (Deibert 1995, p. 92; Bush et al. 2011, p. 528), meaning the actual amount of genetic material contributed to the next generation is smaller than predicted by the number of individuals present in the population. With only 10 to 15 percent of sage-grouse males breeding each year (Aldridge and Brigham 2003, p. 30), the genetic diversity of sage-grouse would be predicted to be low. However, in a recent survey of 16 greater sage grouse populations, only the Columbia Basin population in Washington showed low genetic diversity, likely as a result of long term population declines, habitat fragmentation, and population isolation (Benedict et al. 2003, p. 308; Oyler-McCance et al. 2005, p. 1307). The level of genetic diversity in the remaining range of sage-grouse has generated a great deal of interest in the field of behavioral ecology, specifically sexual selection (Boyce 1990, p. 263; Deibert 1995, p. 92-93). There is some evidence of off-lek copulations by subordinate males, as well as multiple paternity within one clutch (Connelly et al. 2004, p. 8-2; Bush 2009, p. 108). Dispersal also may contribute to genetic diversity, but little is known about dispersal in sage-grouse (Connelly et al. 2004, p. 3-5). However, the lek breeding system suggests that population sizes in sage-grouse would need to be greater than in non-lekking bird species to maintain long-term genetic diversity.

Aldridge and Brigham (2003, p. 30) estimated that up to 5,000 individual sage-grouse may be necessary to maintain an effective population size of 500 birds. Their estimate was based on individual male breeding success, variation in reproductive success of males that do breed, and the death rate of juvenile birds. We were unable to find any other published estimates of minimal population sizes necessary to maintain genetic diversity and long-term population sustainability in sage-grouse. However, the minimum viable population size necessary to sustain the evolutionary potential of a species (retention of sufficient genetic material to avoid the effect of inbreeding depression or deleterious mutations) has been estimated as high as an adult population of 50,000 individuals (Traill et al. 2010, p. 3). Many sage-grouse populations have already been estimated at well below that value (see Garton et al. 2011 and discussions under Factor A), suggesting their evolutionary potential (ability to persist long-term) has already been compromised if that value is correct.

Habitat fragmentation may result in a loss of genetic diversity by changing the frequency an allele will occur in a population simply due to separation of individuals or populations (genetic drift) (Bush et al. 2011, p. 528). Research conducted on sage-grouse in Canada and northern Montana determined that agricultural conversions of sagebrush over the past 30 to 100 years resulted in a large barrier to genetic flow between populations, allowing for their differentiation (Bush et al. 2011, p. 537). Examination of genetic drift occurring in other populations that have experienced habitat fragmentation did not show the same pattern, although the researchers hypothesized that the loss of habitats were too recent to be reflected genetically at the time of sampling (Bush et al. 2011, p. 537). These results, which suggest that distance may limit gene flow in sage-grouse, do suggest that habitat fragmentation negatively affects genetic diversity in this species. This is compounded by the reduction in the number of birds resulting from habitat loss (a reduction in habitat carrying capacity) (Bush et al. 2011, p. 539).

Drought

Drought is a common occurrence throughout the range of the greater sage-grouse (Braun 1998, p. 148) and is considered a universal ecological driver across the Great Plains (Knopf 1996, p.147). Infrequent, severe drought may cause local extinctions of annual forbs and grasses that have invaded stands of perennial species, and recolonization of these areas by native species may be slow (Tilman and El Haddi 1992, p. 263). Drought reduces vegetation cover (Milton et al. 1994, p. 75; Connelly et al. 2004, p. 7-18), potentially resulting in increased soil erosion and subsequent reduced soil depths, decreased water infiltration, and reduced water storage capacity. Drought also can exacerbate other natural events such as defoliation of sagebrush by insects. For example, approximately 2,544 km2 (982 mi2) of sagebrush shrublands died in Utah in 2003 as a result of drought and infestations with the Aroga (webworm) moth (Connelly et al. 2004, p. 5-11). Sage-grouse are affected by drought through the loss of vegetative habitat components, reduced insect production (Connelly and Braun 1997, p. 9), and potentially exacerbation of WNv infections as described in Factor C above. These habitat component losses can result in declining sage-grouse populations due to increased nest predation and early brood mortality associated with decreased nest cover and food availability (Braun 1998, p. 149; Moynahan 2007, p. 1781).

Sage-grouse populations declined during the 1930s period of drought (Patterson 1952, p. 68; Braun 1998, p. 148). Drought conditions in the late 1980s and early 1990s also coincided with a period when sage-grouse populations were at historically low levels (Connelly and Braun 1997, p. 8). From 1985 through 1995, the entire range of sage-grouse experienced severe drought (as defined by the Palmer Drought Severity Index) with the exceptions of north-central Colorado (MZ II) and southern Nevada (MZ III). During this time period drought was particularly prevalent in southwestern Wyoming, Idaho, central Washington and Oregon, and northwest Nevada (University of Nebraska 2008a). Abnormally dry to severe drought conditions still persist in Nevada and western Utah (MZ III and IV), Idaho (MZ IV), northern California and central Oregon (MZ V), and southwest Wyoming (MZ II) in 2008 (University of Nebraska 2008b), but those conditions appear to have been alleviated by above normal precipitation in recent months (National Climatic Data Center 2011).

Aldridge et al. (2008, p. 992) found that the number of severe droughts from 1950 to 2003 had a weak negative effect on patterns of sage-grouse persistence. However, they cautioned that drought may have a greater influence on future sage-grouse populations as temperatures rise over the next 50 years, and synergistic effects of other threats affect habitat quality (Aldridge et al. 2008, p. 992). Populations on the periphery of the range may suffer extirpation during a severe and prolonged drought (Wisdom et al. 2011, p. 468).

In summary, drought has been a consistent and natural part of the sagebrush-steppe ecosystem and there is no information to suggest that drought was a cause of persistent population declines of greater sage-grouse under historic conditions. However, drought impacts on the greater sage-grouse may be exacerbated when combined with other habitat impacts that reduce cover and food (Braun 1998, p. 148).

Numerous factors have caused sage-grouse mortality, and probably morbidity, such as pesticides, contaminants, as well as factors that contribute to direct and indirect disturbance to sage-grouse and sagebrush, such as recreational activities. Drought has been correlated with population declines in sage-grouse, but is only a limiting factor where habitats have been compromised. Although we anticipate use of pesticides, recreational activities, and fluctuating drought conditions to continue indefinitely, we did not find any evidence that these factors, either separately, or in combination are resulting in local or range-wide declines of greater sage-grouse. New information regarding minimum population sizes necessary to maintain the evolutionary potential of a species suggests that sage-grouse in some areas throughout their range may already be at population levels below that threshold, and that there may be impacts to the genetic diversity of this species. This is a result of habitat loss and modification. However, data do not support a rangewide impact of small population sizes. We have concluded that other factors, as described above, are not a significant threat to greater sage-grouse.

Conservation Measures Planned or Implemented :

CONSERVATION MEASURES PLANNED OR IMPLEMENTED
There are 66 local conservation plans for the greater sage-grouse across its range (Stiver et al. 2006, pp. 2-20 – 2-22). Local conservation plans address populations or subpopulations of sage-grouse, providing site-specific provisions for land management activities. The groups responsible for developing and implementing these plans are usually composed of local landowners, county and other local officials, and state and federal agency personnel. Given their focused nature, local conservation plans can have the greatest impact on sage-grouse and their habitats at local scales (Stiver et al. 2006, p. 2-3), and provide the foundation for range-wide conservation (Stiver et al. 2006, p. 2-2). Several conservation efforts have been implemented by these local working groups, many of which are discussed below. Given the time necessary between implementation of the conservation projects and when restored habitats become functional, realized benefits are currently minimal. This will change as restored habitats mature. Many more efforts are planned, but funding and opportunities are frequently limiting.

State and Provincial conservation plans identify threats, issues and opportunities for sage-grouse conservation within their political boundaries. These State and Provincial plans also provide a supporting framework that can facilitate the development and implementation of local plans, and address issues and needs that cannot adequately be considered at the local scale (Stiver et al. 2006, p. 2-2). Each state within the range of the greater sage-grouse has developed a conservation plan for their state. Alberta has developed a recovery plan. Saskatchewan does not have a Provincial plan, but incorporates tenets of both the Alberta recovery plan and the Canadian sage-grouse Recover Strategy into their management activities. These plans cumulatively encompass all greater sage-grouse habitats across the species range (Stiver et al. 2006, p. 2-3). Some of these plans are currently under revision to incorporate updated scientific information, with resulting alterations in management strategies. While most of the conservation strategies follow state or provincial boundaries, some plans have been drafted to address populations that cross state boundaries, such as Nevada and California (Stiver et al. 2006, p. 2-3). As with local conservation efforts, realized benefits will be limited until restored habitats mature.

The Western Association of Fish and Wildlife Agencies (WAFWA) has also completed a comprehensive conservation strategy (Stiver et al. 2006, entire), which identifies needs across the entire species range. This plan delineates the seven management Zones (MZ), using floristic provinces to reflect the ecological and biological issues and similarities (Stiver et al. 2006, p. 1-6) (see also discussion under Habitat/Life History above). A MOU pledging cooperation amongst participating agencies to implement the strategy was signed by all the States and Provinces within the species' range as well as the U.S. Fish and Wildlife Service, the Bureau of Land Management, the U.S. Geological Survey, the U.S. Forest Service, the Natural Resources Conservation Service and the Farm Services Agency. The MOU provides continuing support for all working groups to develop and implement all state, provincial and local conservation plans. Additionally, the MOU created two interagency teams to facilitate implementation of the comprehensive conservation strategy. Both teams are currently actively engaged in finding opportunities to implement the strategy. Additionally, two research needs identified in the comprehensive strategy are actively being pursued – research to determine the effects of wind energy development and the effects of tall structures on sage-grouse. Both efforts are in preliminary stages of development and no results of their work are currently available.

As discussed under the regulatory mechanisms section above, several states have developed core area strategies, or similar mechanisms, to conserve vital habitats within their states. The State of Wyoming's core area strategy is the most fully developed effort at this time. Other states either have developed, or are in the process of, developing similar strategies, although they may have different nomenclature (e.g. Montana, Nevada, Oregon). As discussed above (see regulatory mechanisms section), Federal agencies in those states are developing policies, until RMP revisions can be completed, to assist in these efforts on Federal lands. Given the recent, and ongoing development of these efforts, their contributions to the long-term conservation of the greater sage-grouse cannot not currently be determined at this time. However, the Service believes these efforts, if based on the best available science and fully implemented, can provide significant contributions to the long-term conservation of this species.

Many tribes with sage-grouse resources have participated in local and state conservation efforts (Stiver et al. 2006, p. 2-6). Some tribes have developed their own conservation plan (e.g. Duck Valley Indian Reservation), and several others are working on drafts (Stiver et al. 2006, p. 2-6). Native American participation in overall sage-grouse planning efforts has been significant (Stiver et al. 2006, p. 2-6).

The Canadian Sage Grouse Recovery Strategy was released in July, 2001. The goal of this strategy is to provide recommendations to allow sage-grouse populations to recover to self-sustaining levels so that the species can be removed as an endangered species under the Species at Risk Act.

In 2010, the NRCS implemented the Sage-Grouse Initiative (SGI), a science-based, landscape scale approach to deliver conservation actions on private lands to address habitat threats as identified in our March 2010 status review (75 FR 13910). The SGI uses Farm Bill conservation program funds (Environmental Quality Incentives Program (EQIP) and Wildlife Habitat Incentive Program (WHIP)), and obligated 20 million dollars in financial assistance to 246 contracts for sage-grouse conservation on private lands in 2010. (NRCS 2011, in litt..). The NRCS is also using their Farm and Ranch Protection Program (FRPP) to develop conservation easements on private ranches with habitat essential to the long-term conservation of the sage-grouse. These easements protect important seasonal and migratory habitats from habitat fragmentation. In Wyoming, over 20 million dollars were obligated in 2010 for conserving large tracts of sage-grouse habitats, as well as other grassland avian species and mule deer (WY NRCS 2011, in litt.). The NRCS is also engaging in important research activities to further the understanding of the value of habitat manipulation and restoration techniques to the species. The SGI is expected to continue for several years, providing significant habitat protection and restoration through management. Although habitat restoration efforts may not yield immediate results, long-term benefits are likely. Additionally, reducing the opportunities for future habitat fragmentation is essential for the long-term conservation of the species. The NRCS is working closely with the Intermountain Joint Ventures Program to build capacity for delivery of private land restoration projects under the SGI. The Service believes the SGI will provide significant conservation benefit to the greater sage-grouse on private lands throughout the species range.

In 2004, the BLM developed a National Sage-grouse Habitat Conservation Strategy which established broad goals for improving the effectiveness of management frameworks for conservation needs of sage-grouse on BLM lands, increasing the understanding of resource conditions to prioritize habitat maintenance and restoration, and to ensure implementation of national and state-level sage-grouse habitat conservation strategies. We have not received a description of specific actions taken under this plan; however the BLM has actively identified conservation needs, and developed associated conservation activities for the greater sage-grouse on their lands (see descriptions under regulatory mechanisms section above). In 2010, the USFS completed initial restoration efforts on 8,304 ha (20,521 ac) of sage-grouse habitats (USFS 2011, pers. comm.). An additional 56,972 ha (140,780 ac) were inventoried to determine habitat condition and restoration needs. We did not receive information regarding the success of the restoration efforts, nor the needs identified in the habitat condition inventory. However, the efforts by both the BLM and USFS are contributing to conservation of the sage-grouse on Federal lands.

Candidate Conservation Agreements with Assurances (CCAA) are voluntary agreements whereby private landowners agree to manage their lands to remove or reduce threats to species at risk. In return landowners receive assurances against additional regulatory requirements should that species ever be listed. CCAAs are only applicable to non-Federal lands, as Federal agencies cannot receive assurances should a species become listed. However, Federal agencies can develop Candidate Conservation Agreements (CCAs) to effect conservation actions on lands under their management. One CCAA for the greater sage-grouse has been completed and implemented in west-central Idaho. A second is nearing completion in Wyoming, with concurrent development of a CCA for associated federal lands. These agreements address the effects of grazing and ranch management activities. Additional CCAAs are being considered across the species' range, but none have been developed to the extent that we can evaluate their effectiveness on reducing and removing threats.

Greater sage-grouse conservation actions have also been initiated by several entities independent of local, State, or Provincial plans. For example, many industries working in sage-grouse habitats have implemented habitat restoration activities for disturbances they did not create. For the March 2010 status review, we received summaries of of 1,763 conservation efforts (inclusive of local, State, Provincial, and independent efforts), totaling an estimated 96,454 km2 (23,834,413 ac). Many of these conservation efforts (68) did not address threats that are considered as contributing to the candidate status of the species (e.g. drowning, drought, hunting, recreational activities). While conservation efforts focused on these activities can address local concerns, they were not considered further in our rangewide analyses did not address a primary threat. The other conservation efforts were all related to habitat impacts. However, some of these efforts were actually required mitigation for development projects in sagebrush habitats, and therefore are not considered voluntary conservation actions.

Many of the conservation efforts (712, encompassing 51,357 km2 (12,690,591 ac)) were to generally improve wildlife habitat or rangeland health, and were not specific to greater sage-grouse conservation. While improving rangeland health will generally have conservation benefits for sage-grouse, we cannot assess their specific benefits for conservation of the greater sage-grouse. Additionally, many conservation efforts addressed livestock management activities on private lands. Due to the need to protect the identity and location of the associated landowners, the data provided were insufficient to determine the actual value of the conservation effort for the greater sage-grouse.

The remaining 983 conservation efforts affect approximately 32,837 km2 (8,114,300 ac) of sagebrush habitat, including activities focused on agricultural activities, conifer encroachment, energy development, fire management, grazing, habitat conversion, habitat degradation, invasive nonnative plants, mining, project infrastructure, and urbanization. These efforts occurred across the species range within the United States (Table 6). We received no information regarding conservation efforts for Canada.

TABLE 6. Number of efforts and acres for conservation efforts addressing habitat concerns. Data are from efforts submitted to the Service.

Activity	CA	CO	ID	MT	ND	NV	OR	SD	UT	WA	WY
Ag activities	--	--	--	6/3,120	--	--	--	--	4/56,031	--	--
Conifer encroachment	3/4,880	9/12,762	3/2,770	1/213	--	50/31,357	54/48,646	--	119/119,918	--	3/1,985
Energy development	--	4/57,700	--	--	--	--	--	--	--	--	136/78,928
Fire management	--	--	10/7,424	--	--	--	1/405	--	15/30,924	6/415,503	1/5,000
Grazing	1/93	24/182,396	42/11,863	--	--	13/1,907,005	--	--	37/313,539	--	15/454,339
Habitat conversion	1/161	1/2,500	18/3,178	35/186,313	--	3/3,100	--	--	32/34,234	--	2/50,150
Habitat degradation	3/355	73/25,269	27/10,104	--	--	17/1,183,418	12/32,165	--	98/744,554	10/1,724,073	27/89,244
Invasive plants	--	2/530	7/9,346	--	--	8/23,866	1/1,600	--	25/21,880	--	17/19,815
Mining	--	--	--	1/700	--	--	--	--	--	--	--
Project infrastructure	--	--	2/6,029	--	--	--	--	--	--	1/**	--
Urbanization	--	26/45,406	--	--	--	1/9,944	--	--	9/85,344	--	5/45,088

** acres not reported

As identified in Table 6, many of the efforts to address habitat threats occurred at a limited scale, or do not occur within part of the species' range where the threat is predominant. For example, the average size of conservation efforts addressing invasive plants in Nevada, an issue of concern there, is 12 km2 (2,983 ac). While Wyoming had 17 conservation actions addressing impacts from invasive plants, it is not a primary threat there. Of the efforts listed in Table 6, only 683 were fully implemented, affecting 7,802 km2 (1,927,878 ac). While the remaining efforts gave reasonable assurances that implementation would occur, that has not yet occurred. If all efforts are implemented and effective, approximately one percent of the entire species' range will receive conservation benefits. Given the scattered nature of these efforts, they do not ameliorate the effects of habitat fragmentation resulting from agricultural activities, conifer encroachment and invasive plants, energy development, fire management, grazing, habitat conversion and degradation, project infrastructure, and urbanization at a sufficient scale range-wide to effectively reduce or eliminate these most significant threats to the species.

We have received information on four additional independent conservation efforts since our March 2010 status review (Andarko Petroleum 2011, pers. comm.; Fidelity Exploration 2011, pers. comm.). Reclamation seeding of energy development sites totaled 916 ha (2,263 ac) (Anadarko Petroleum 2011, pers. comm.), and 526 ha (1,300 ac) of private land were treated to remove invasive grasses (Fidelity Exploration 2011, pers. comm.). Fidelity Exploration is also currently raptor-proofing their well locations to minimize perch and nesting locations for predators. These projects are occurring in western Wyoming. One additional company provided an update on several conservation efforts provided for our March 2010 status review, although it was not clear which items were required as mitigation for their energy development activities (Yates Petroleum 2011, pers. comm.). This included several reclamation projects to restore native vegetation to areas disturbed by development (minimally 1,015.8ha, (2,510 ac)), implementation of timing restrictions to avoid disturbance to mating grouse, and minimization of project footprint to conserve habitats (Yates Petroleum 2011, pers. comm.). These activities are occurring across energy developments in Wyoming and northwestern Colorado.

We recognize the long list conservation efforts by all entities across the range of the greater sage-grouse. All parties should be commended for their conservation efforts. Our review of conservation efforts indicates that the measures identified are not adequate to address the primary threat of habitat fragmentation at this time in a manner that effectively reduces or eliminates the most significant contributors (e.g., energy development) to this threat. Many of the conservation efforts are limited in size and are scattered across the entire range of the species. Most are early in implementation, and habitat benefits have not yet been realized. In many cases the measures provided to us were simply not cumulatively implemented at the scale that would be required to effectively reduce the threats to the species across its range. Although the ongoing conservation efforts are a positive step toward the conservation of the greater sage-grouse, and some have likely reduced the severity of some threats to the species (e.g., pinyon-juniper treatments, see discussion under Factor A above), on the whole we find that the conservation efforts in place at this time are not sufficient to offset the degree of threat posed to the species by habitat fragmentation.

Summary of Threats :

<u>Summary of Factor A</u>

Greater sage-grouse are a landscape-scale species requiring large, contiguous areas of sagebrush for long-term persistence. Large-scale characteristics within surrounding landscapes influence habitat selection, and adult sage-grouse exhibit a high fidelity to all seasonal habitats, resulting in little adaptability to changes. Fragmentation of sagebrush habitats has been cited as a primary cause of the decline of sage-grouse populations (Patterson 1952, pp. 192-193; Connelly and Braun 1997, p. 4; Braun 1998, p. 140; Johnson and Braun 1999, p. 78; Connelly et al. 2000a, p. 975; Miller and Eddleman 2000, p. 1; Schroeder and Baydack 2001, p. 29; Johnsgard 2002, p. 108; Aldridge and Brigham 2003, p. 25; Beck et al. 2003, p. 203; Pedersen et al. 2003, pp. 23-24; Connelly et al. 2004, p. 4-15; Schroeder et al. 2004, p. 368; Leu et al. in press, p. 19). The primary factors that result in habitat loss and fragmentation for the greater sage-grouse include conversion of sagebrush for agriculture, urbanization, shorter wildfire cycles as facilitated by the invasive Bromus tectorum (cheatgrass), renewable and non-renewable energy development, and poor management of domestic livestock and wild horse. These threats have intensified over the last two decades, and as we predicted in our March 2010 status review (75 FR 13958), they are continuing to accelerate due to the positive feedback loop between fire and invasives and the persistent and increasing demand for energy resources. Restoration of sagebrush habitat is challenging, and restoring habitat function may not be possible because alteration of vegetation, nutrient cycles, topsoil, and cryptobiotic crusts have exceeded recovery thresholds.Population trends and habitat fragmentation.

In our March 2010 status review we examined the effects of habitat loss and fragmentation on greater sage-grouse populations and persistence using a variety of data to understand how population trends reflected the changing habitat condition (75 FR 13958-13961). Patterns of sage-grouse extirpation were identified by Aldridge et al. 2008 (entire) Johnson et al. (in press, entire), Wisdom et al. (in press, entire), Knick and Hanser (in press, entire), and others, and discussed in detail above. Fire, agricultural activities, human densities, and energy development were all identified as risks. Therefore, where these habitat factors, and others identified above, are occurring, we anticipate that sage-grouse population trends will continue to decline. This is evidenced by observed declines in sage-grouse population trends (e.g. a decrease of 30 percent from 1965 to 2007 in MZ II (Garton et al. in press, p. 35) where intensive energy development is occurring). Details of population trends by MZs and the associated activities contributing to habitat fragmentation can be found in our March 2010 status review (75 FR 13958-13961). We found no evidence in this annual review that this trend of impacts is declining, and there were no significant increases in sage-grouse populations.

We examined the persistence of each of these habitat threats on the landscape to help inform a determination of foreseeable future. Habitat conversion and fragmentation resulting from agricultural activities and urbanization will continue indefinitely. Human populations are increasing in the western United States and we have no data indicating this trend will be reversed. Increased fire frequency as facilitated by the expanding distribution of invasive plant species will continue indefinitely unless an effective means for controlling the invasives is found. In the last approximately 100 years, no broad scale Bromus tectorum eradication method has been developed. Therefore, given the history of invasive plants on the landscape, our continued inability to control such species, and the expansive infestation of invasive plants across the species' range currently, we anticipate they and associated fires will be on the landscape for the next 100 years or longer.Continued exploration and development of traditional and nonconventional fossil fuel sources in the eastern portion of the greater sage-grouse range will continue to increase over the next 20 years (EIA 2009b, p. 109). Based on existing National Environmental Policy Act (NEPA) documents for major oil and gas developments, production within existing developments will continue for a minimum of 20 years, with subsequent restoration (if possible) requiring from 30 to 50 additional years. Renewable energy development is estimated to reach maximum development by 2030. However, since most renewable energy facilities are permanent landscape features, unlike oil, gas and coal, direct and functional habitat loss from the development footprint will be permanent.Grazing (both domestic and wild horse and burro) is unlikely to be removed from sagebrush ecosystems. As of 2007, there were 7,118,989 permitted AUMs in sage-grouse habitat. Although there have been recent reductions in the number of AUMs (3.4 percent since 2005), we have no information suggesting that livestock grazing will be significantly reduced, or removed, from sage-grouse habitats.

The habitat threats identified above are contributing to significant habitat fragmentation, which is negatively affecting the greater sage-grouse. Population and carrying capacity projections suggest that some current populations will be extirpated within the foreseeable future, with many others experiencing large population declines and losses of carrying capacity. As populations lose connectivity and become smaller, they will become increasingly vulnerable to genetic, demographic, and environmental stochastic events. We have evaluated the best available scientific information on the present or threatened destruction, modification or curtailment of the greater sage-grouse's habitat or range. Based on the current and ongoing habitat issues identified here, and their synergistic effects, we have determined that this factor poses a significant threat to the species throughout its range.

Summary of Factor B

We have no evidence suggesting that any use of the greater sage-grouse (recreational hunting, poaching, or scientific or religious use) is currently at levels that pose a threat to the species. Although harvest as a singular factor does not appear to threaten the species throughout its range, negative impacts on local populations have been demonstrated and there remains a large amount of uncertainty regarding harvest impacts because of a lack of experimental evidence and conflicting studies. Significant habitat loss and fragmentation have occurred during the past several decades, and there is evidence that the sustainability of harvest levels depends to a large extent upon the quality of habitat and the health of the population. To date, adaptive management principles employed by state wildlife agencies have addressed these concerns. We do not believe data support overuse of sage-grouse as a singular factor in rangewide population declines.

Summary of Factor C

The only disease of sage-grouse hat has the potential to limit populations is West Nile virus (WNv). This disease is distributed throughout the species' range and affected sage-grouse populations experience high mortality rates (near 100 percent lethality), with resultant reductions in local population numbers. The continued development of anthropogenic water sources throughout the range of the species will likely increase the prevalence of the virus in sage-grouse. However, the occurrence of WNv occurrence is sporadic across the species' range, and a complex set of environmental and biotic conditions that support the WNv cycle must coincide for an outbreak to occur. Where habitat is not limited and is of good quality, predation is not a threat to the species. However, continued habitat fragmentation will contribute to the spread of human-subsidized predators in sagebrush habitats, potentially resulting in significant impacts to sage-grouse. Based on the best scientific and commercial information available, we conclude that disease and predation are not currently significant threats to the species.

Summary of Factor D

There are no current local land use or development planning regulations or private land regulations that provide adequate protection to sage-grouse. Changes incorporated into the 2008 Farm Bill are likely to negatively impact private lands currently enrolled in the CRP program that are providing sage-grouse habitats. States regulatory mechanisms to protect sage-grouse from development activities are limited to Colorado and Wyoming. These regulations do not apply to existing developments, and in some cases, are voluntary. However, they do present opportunities for sufficient regulatory authorities if fully developed. The majority of sage-grouse habitat in the United States is managed by Federal agencies. The BLM is actively pursuing RMP revisions and amendments, many of which will provide regulatory mechanisms to address sage-grouse conservation. However, none have been completed and therefore final alternatives and their resultant effects on grouse cannot be assessed. The development of Travel Management Plans on Forest Service lands may provide benefits in those areas where motorized travel was impact the species. However, we received no information on currently realized benefits. Guidance from the Chief of the Forest Service for the management and conservation of sage-grouse and their habitats on Forest Service lands lacked specific information and provided no regulatory mechanisms for implementation. We found no regulatory mechanisms currently in place to address sage-grouse conservation on other Federal lands. Therefore, we conclude that existing regulatory mechanisms are inadequate to protect the greater sage-grouse. While many mechanisms are proposed, they are incomplete, and their final disposition is unknown.

Summary of Factor E

Numerous factors have caused sage-grouse mortality, and probably morbidity, such as pesticides, contaminants, as well as factors that contribute to direct and indirect disturbance to sage-grouse and sagebrush, such as recreational activities. However, we could find no data that demonstrates these factors are contributing to a rangewide decline of the greater sage-grouse, and therefore conclude that they are not significant threats to this species.

For species that are being removed from candidate status:

_____ Is the removal based in whole or in part on one or more individual conservation efforts that you determined met the standards in the Policy for Evaluation of Conservation Efforts When Making Listing Decisions(PECE)?

Recommended Conservation Measures :

In our discussion of local conservation efforts, we identified that many had not yet realized their full potential simply due to the length of time necessary for habitat restoration activities to actually provide a benefit to sage-grouse. We also expressed concerns about the size and patchiness of these efforts. However, the Service recognizes that local solutions are vital to the long-term conservation of these species, and that the on-going conservation efforts identified above need to continue with careful monitoring and appropriate adaptive management efforts. We encourage a more collaborative approach to future efforts to avoid duplication of efforts and to facilitate prioritization of conservation efforts to affect the most benefit. Collaborative efforts should also apply to State and Provincial conservation plans, on-going and proposed Candidate Conservation Agreements, and regulatory core area strategies being considered by several states. In addition, the comprehensive conservation strategy developed by WAFWA needs to be fully supported and implemented. We identified two listing factors as contributing to our determination of the species status in our March 2010 status review (75 FR 13986-13987): habitat fragmentation and the inadequacy of regulatory mechanisms. Given the site fidelity for all seasonal habitats expressed by this species, we recommend that no sagebrush habitats should be lost, either through direct removal, or by fragmentation. We encourage consideration of all opportunities to reduce habitat loss and fragmentation, such as consolidation of infrastructure, zoning regulations, elimination of sagebrush removal projects, and other measures as appropriate. Examples of these types of efforts can be found in the Wyoming Governor's Executive Order (discussed above), and a description of conservation planning using core areas provided by Naugle et al. (2011, pp. 64-70). To address fragmentation resulting from natural events, such as wildfire, restoration of habitat should commence immediately. This restoration should entail the development of techniques and materials to restore not only sagebrush, but the critical understory essential for sage-grouse persistence. Regulatory mechanisms should be enhanced, or developed to allow for long-term, landscape-scale habitat conservation. This action should include regulatory mechanisms for lands under Federal management, as well as State and private lands. Efforts such as the NRCS SGI and state core area strategies with regulatory authorities should continue long-term. Incentive based efforts, such as CCAAs also need to be developed and/or continued. These cumulative efforts are essential for reducing threats to the greater sage-grouse and its habitats.

Priority Table

Magnitude	Immediacy	Taxonmomy	Priority
High	Imminent	Monotypic genus	1
		Species	2
		Subspecies/Population	3
	Non-imminent	Monotypic genus	4
		Species	5
		Subspecies/Population	6
Moderate to Low	**Imminent**	Monotypic genus	7
		Species	**8**
		Subspecies/Population	9
	Non-Imminent	Monotype genus	10
		Species	11
		Subspecies/Population	12

Rationale for Change in Listing Priority Number:

not applicable

Magnitude:

In our March 2010 status review, we assigned the greater sage-grouse an LPN of 8 based on our finding that the species faces threats that are of moderate magnitude and high imminence, including the present or threatened destruction, modification or curtailment of its habitat and the inadequacy of existing regulatory mechanisms (75 FR 14008). Following this review, we still consider the threats the greater sage-grouse faces to be moderate in magnitude because the threats are not occurring with uniform intensity or distribution across the wide distribution of the species at this time. Examples include oil and gas development, which is extensive in the eastern part of the range but limited in the western portion; pinyon-juniper encroachment, which is substantial in some parts of the western part of the range, but is of less concern in Wyoming and Montana, and agricultural development, which is extensive in the Snake River Plain and eastern Montana, but more limited elsewhere. Where threats are occurring, they are not currently of such magnitude that the entire species requires listing immediately to ensure its continued existence. In this annual review of the species' status, several development projects were identified which we were unaware of during our March 2010 status review. Some of these projects, if constructed as currently proposed, will impact populations that currently have few or no threats (e.g. Mountain States Transmission Intertie), or will add to cumulative impacts(e.g. China Mountain Wind Project), potentially increasing the magnitude of the threats in a wider portion of the species' range. However, these projects are currently proposed, and final environmental analyses are not completed. Therefore, we cannot definitively state that the impacts from the proposed actions will occur. These projects will be monitored, and be re-evaluated during our subsequent annual reviews.

While sage-grouse habitat has been lost or altered in many portions of the species' range, substantial habitat still remains to support the species in many areas of the range (Connelly et al. in press c, p. 23), such as higher elevation sagebrush, and areas with a low human footprint (activities sustaining human development) such as the Northern and Southern Great Basin (Leu and Hanser in press, p. 14). The species also has a wide distribution across 11 western states and two Provinces. In addition, two strongholds of contiguous sagebrush habitat (the southwest Wyoming Basin in and the Great Basin area straddling the States of Oregon, Nevada, and Idaho) contain the highest density of males in the range of the species (Wisdom et al. in press, pp. 24-25; Knick and Hanser in press, p. 17). We believe that the ability of these strongholds to maintain high densities in the presence of several threat factors is an indication that the magnitude of the threats is moderate overall. Additionally, newly forming regulatory mechanisms are likely to provide significant protection for these areas, such as the Wyoming Governor's Executive Order, and proposed core area strategies in other key areas (e.g. Oregon, Nevada). We also lack data on the actual future location of where some potential threats will occur (e.g. location of the next wildfire). If these threats occur within unoccupied habitat, the magnitude of the threat to greater sage-grouse would be greatly reduced.

Guidelines for managing sage-grouse habitats have been identified and the priority of retaining habitat is part of the rangewide strategy for long-term conservation (Stiver et al. 2006, p. 1-2). There are also many conservation efforts underway that would abate (although not eliminate) the threats. Notably, the NRCS' SGI will provide significant resources to reduce or remove threats, including habitat fragmentation, on private lands throughout the range of the greater sage-grouse. Therefore, tools have been identified, and many are currently available to address the threats that are already occurring on the landscape. More than 1,000 conservation efforts to restore sage-grouse habitats are currently on-going (see discussion under Conservation Measures). Connelly et al. (in press c, p. 32) are optimistic that opportunities to conserve sage-grouse throughout their range, despite the ongoing threats, still exist. However, efforts need to address habitat needs and occur on a large scale for effectiveness (Connelly et al. in press c, p. 9).

Lek counts in 2008 resulted in a total of 88,816 males counted on 5,046 leks (Connelly et al. in press c, p. 6). While population trends are declining, sage-grouse numbers are still sufficient to sustain the species if sufficient habitat is conserved. Additionally, the population viability analyses conducted by Garton et al. (in press, entire) suggests that 96% of all populations and MZs will likely remain above an effective population size of 50 for the next 30 years (Connelly et al. in press c, p. 15). We received no information in our most recent data call to indicate that population trends are fluctuating outside of what was expected given population cycles and weather conditions, with the exception of small populations along the periphery of the species' range (North and South Dakota). Both state agencies attributed these declines to habitat quality, and potentially West Nile virus. No West Nile virus was detected anywhere in the species range in 2010.

Therefore, we do not believe the magnitude of threats to the greater sage-grouse across its entire range is of such a high level that the species will be unable to recover if corrective actions are taken. We will continue to monitor the threats to the greater sage-grouse, and the species' status on an annual basis.

Imminence :

We consider the threats imminent because we have factual information that the threats are identifiable and that the species is currently facing them in many portions of its range. These threats include habitat fragmentation from agricultural activities, urbanization, increased fire frequency, invasive plants, and energy development.

__Yes__ Have you promptly reviewed all of the information received regarding the species for the purpose of determination whether emergency listing is needed?

Emergency Listing Review

__No__ Is Emergency Listing Warranted?

While sage-grouse habitat has been lost or altered in many portions of the species' range, substantial habitat still remains to support the species in many areas of the range (Connelly et al. in press c, p. 23), and areas with a low human footprint (activities sustaining human development) such as the Northern and Southern Great Basin (Leu and Hanser in press, p. 14). The species also has a wide distribution across 11 western states and two Provinces. In addition, two strongholds of contiguous sagebrush habitat (the southwest Wyoming Basin in and the Great Basin area straddling the States of Oregon, Nevada, and Idaho) contain the highest density of males in the range of the species (Wisdom et al. in press, pp. 24-25; Knick and Hanser in press, p. 17). These strongholds maintain high densities of greater sage-grouse in the presence of several threat factors. While threats to the greater sage-grouse remain, and are increasing in some places, we have no evidence to suggest that the species will not persist for several years.

Description of Monitoring:

Greater sage-grouse population numbers are difficult to estimate due to the large range of the species, physical difficulty in accessing some areas of habitat, the cryptic coloration and behavior of hens (Garton et al. in press, p. 6) and survey protocols (see discussion above under Population Estimates/Status). The annual counting of males on leks remains the primary approach to monitor long-term trends of populations (WAFWA 2008, p. 3), and standardized techniques are beginning to be implemented throughout the species' range (Stiver et al. 2006, pp. 3-1 to 3-16). The use of harvest data for estimating population numbers also is of limited value since both harvest and the population size on which harvest is based are estimates. Given the limitations of these data, States usually rely on a combination of actual counts of birds on leks and harvest data to estimate population size. State wildlife agencies and Federal land management agencies will continue to monitor sage-grouse leks to estimate long-term trends, and State agencies will continue to analyze fall harvest data. Habitat losses are being monitored with the assistance of geo-spatial analyses, and data collection efforts on the part of the Service, other Federal agencies, State agencies, and private entities. Conservation efforts all have a monitoring component, and those results are reported to the Service by the appropriate entities on an annual basis. The Service will also continue to monitor proposed activities which have been identified as a threat to the species or its habitats as that information becomes available. Additionally, scientific literature and commercial data will be continually examined to increase our understanding of both impacts to the species and its habitats, and restoration opportunities.

Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment:

California,Colorado,Idaho,Montana,Nevada,North Dakota,Oregon,South Dakota,Utah,Washington,Wyoming

Indicate which State(s) did not provide any information or comment:

none

State Coordination:

All States provided information and comments for this review. Additionally, we received information from several Tribal governments, the Bureau of Land Management, the U.S. Forest Service, the Natural Resources Conservation Service, and several industry representatives.

The Canadian Provinces of Alberta and Saskatchewan did not provide any information or comments.

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Approval/Concurrence:

Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve: ______________________ 05/31/2011
Date

Concur: ______________________ 10/07/2011
Date

Did not concur: ______________________ ______________
Date

Director's Remarks: